University of Alberta

Collaborative Action Research for Science Teachers' Pedagogical Content Knowledge Enhancement

By

Harcharan Pardhan

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirement for the degree of Doctor of Education

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UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled COLLABORATIVE ACTION RESEARCH FOR SCIENCE TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE ENHANCEMENT submitted by Harcharan Pardhan in partial fulfillment of the requirements for the degree of Doctor of Education.

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In memory of my mother Kartar Kaur Babra, and dedicated to:

The research participants and their students,

My father, Surjan Singh Babra,

My husband, Sadrudin Pardhan,

My sons, Azhar and Amaan Pardhan,

My daughter and son-in-law, Almina Pardhan and Karim Sayani,

My grandson, Azaan Pardhan Sayani.

ABSTRACT

This study, conducted in Pakistan, is an investigation into how science teachers' pedagogical content knowledge can be enhanced through reflective dialogues and narratives. A review of the educational system of Pakistan reveals that education, in particular science education, has received low priority. As a result, the teaching and learning of science has predominantly remained teacher-centered and traditional. However, the current trends in the teaching and learning of science worldwide, including Pakistan, have compelled educators to question teachers' classroom practice and to engage in collaborative efforts to help teachers cope with the challenges to bring about a change in their practice. More importantly, there is a great concern about a need for teachers to acquire a special kind of knowledge termed as 'pedagogical content knowledge' (Shulman, 1986) for effective teaching in today's 'information age' and advanced technological society driven by the global economy.

This study was thus designed to: explore Shulman's 'Pedagogical Content Knowledge' (1986) and its merit for making science teaching and learning more meaningful; provide a framework for teachers to engage in critical self-reflection about their classroom practice in science education; study the process of action research in the space of science education; and describe the influence of collaborative action research as a framework for teacher growth and curriculum development.

The study reports on the experiences of two primary school teachers, one secondary school teacher, and myself, a university researcher/facilitator, as we participated in a collaborative action research project. The inquiry was a qualitative case study that focused on understanding the thinking and beliefs of the project participants. Multiple

methods were used to collect data: audio recording group sessions, relevant documents like lesson plans and children's artifacts, field notes, informal conversations, and journal entries. The project group met every two to three weeks over a period of eight months.

Many encouraging outcomes from the study were witnessed. These include teacher development especially in the subject matter content knowledge and pedagogy specific to science teaching and learning, student learning, and curriculum development. The participants in the research became more reflective about their practice through the process of action research and, hence, enhanced their pedagogical content knowledge in the teaching and learning of science. The students became more engaged in learning science and experienced a science curriculum that became more relevant and personalized. Additionally, the action research process was instrumental in providing a feasible and effective framework for both curriculum development as well as personal and professional development in the pedagogical content knowledge of the participating teachers.

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Chapter 1

SETTING THE SCENE

INTRODUCTION

In today's 'information age' and advanced technological society that is being driven by the global economy, science education is radically transformed and challenged. Educators worldwide are being compelled to question teachers' practice and engage in collaborative research to help them cope with challenges to bring about change in their practice. Science teachers are required to teach more than mere facts and rote memorization. They are expected to teach to "promote comprehension among students" (Shulman, 1987, p. 8). For this, teachers are expected to develop a special dimension to their knowledge base. Shulman (1987) has termed this teacher knowledge as 'pedagogical content knowledge.' This he defines as teachers' knowledge of a subject from the perspective of teaching that subject.

I have been a teacher and teacher educator in math and science at different levels, in different capacities, and in different countries (Kenya, Canada, and Pakistan) since 1970. Initially, I followed a predominantly 'transmission' mode of discourse. It worked for me and was the most comfortable method for me. Since 1994 I have worked in Karachi, Pakistan at the Aga Khan University Institute for Educational Development, which has been instrumental in educational reform in the developing countries to improve teachers' classroom practices and to make them more compatible with those of many other countries of the world. Co-ordinating and facilitating various in-service teacher education programs at this institution as well as emphasizing 'reflective practice' and 'constructivism' for change in teachers' practice has made me realize the power of teachers as 'transformers' of knowledge rather than mere 'transmitters' of knowledge. Education, in general, and science education, in particular, in Pakistan has received low priority in the history of Pakistan. As a result, a large majority of teachers in Pakistan are inadequately prepared both academically and professionally. As a result, the teaching/learning is predominantly teacher-centered. Working with these teachers, I have come to appreciate their struggles and constraints to bring about change in their practice and, in the process, to enhance their pedagogical content knowledge. This motivated me

to pursue this study to enable me to gain a deeper, contextual understanding about science teacher development and science education in teacher development.

This study was based in Karachi schools affiliated with the Aga Khan University Institute for Educational Development. It focuses on the enhancement of pedagogical content knowledge of three science teachers. Two of them teaching class levels one to five and the third one teaching classes nine and ten. It consists of seven chapters. The first chapter gives the contextual background in which this question arose and my personal perspectives that influenced my interest in science teachers' pedagogical content knowledge and curriculum change. The second chapter addresses the theoretical framework of the research including the tensionalities of different science pedagogies in teacher education, and the third chapter deals with the research methodology and ethical considerations. The next three chapters in chronological order (see chapter 3, fig. 3.1, p.28) look at: explorations of the teachers' initial classroom practice and concerns; collaborative strategic planning and actions; critical reflections on the research findings and a discussion of these findings. The seventh chapter is devoted to final reflections, learnings, and implications of the study.

The Current State of Education in Pakistan

Pakistan has a population of 130 million (Hakim, 1997; Newsline Editor). Predominantly an agricultural country, Pakistan has just celebrated its fiftieth year of independence from colonial rule. Urdu is the national language understood throughout the country. The most common regional languages are Punjabi, Sindi, Pashtu, and Baluchi. English is used mainly in commercial, legal, and most official transactions. Pakistan's literacy rate of 35% is depressingly low; such poor literacy is due to the following reasons: high population growth rate, cultural barriers (especially of female education), and low level of socio-economic development (The World Bank, 1993).

Since the 70s, policies attempting to relate the educational system to the needs of an independent sovereign state have been discouraging. Government attempts to set up commissions such as the Literacy and Mass Education Commission (LAMEC, 1981) and simultaneous programs initiated by universities like Allama Iqbal Open University to

promote literacy have not yet helped to overcome the illiteracy problem that may be responsible for the slow growth and development of Pakistan.

Politically, Pakistan is unstable. Since its independence in 1947, democratically elected governments as well as powerful military dictatorships have ruled. For the last eleven years, eight different governments have come into power for short periods of time. Unfortunately, four of these democratic governments had to be removed on the basis of corruption. Pakistan's economy is also in a poor state. Its present debt stands at 63 billion dollars, 23 billion being domestic debt and 40 billion in foreign debts. In 1995-96 about 47% of expenditure went towards debt servicing and 26.9% for defense (Hakim, 1997; Newsline Editor) leaving little for the development of education or social programs. Pakistan continues to face major difficulties such as underdevelopment, political instability, and religious and ethnic problems among various sections of its population.

Pakistan has one of the worst records in terms of the education of its children (Zuberi, 1993; Business Recorder Editor). It has a very poor record in primary education (Warwick & Reimers, 1995, p. 139). School enrollment and retention rates are lower in Pakistan than in poorer countries in Africa and South Asia. In 1990, only 37% of all eligible children in Pakistan were enrolled in primary schools. It is estimated that only about 57% of students enrolled in class one complete class five (UNESCO, 1991). The situation is worse in rural areas and among females. In the mid 1980s, less than one in six girls in rural Pakistan completed five years of education. Only three percent of rural girls were still in school by the age of twelve and less than one percent remained in school by the age of fourteen. Less than half of all rural boys completed primary school and only seven percent were still in school at the age of fourteen (The World Bank, 1988, p. 4). This is due to the low priority assigned to education in national development plans; worse still, actual expenditures have fallen below planned targets. This is especially true of primary education (ibid, p. 4).

The existing school facilities are uneven in terms of quality (curriculum, subject matter, teaching methodologies, assessment/evaluation policies and procedures, and student evaluation) of education and are distributed unevenly between urban and rural areas. Because of the difficulty of effecting improvement in access to and quality of

education on any significant scale in the public sector, the government has allowed the development of private schools. Besides the government-run schools, business interests, religious organizations, community groups, and secular philanthropists have also established private schools.

In Pakistan, curriculum planning and development is centralized. Textbooks are prepared and published by the provincial textbook boards. Schools are discouraged from devising their own curricula or from using textbooks other than those prescribed by the government. This can be exemplified by one of the circulars[1] issued by the Sindh Province which indicated that all heads of schools, teachers, parents, and students should ensure that only the textbooks prepared and published under the authority of the Sindh Textbook Board are to be purchased and used in classroom (Sindh Textbook Board, 1986-87). Evaluation (predominantly summative) based on paper pencil tests and centralized examinations call for students to regurgitate the facts they have memorized.

The predicament of teacher training is paramount, with severe problems of quality. This bleak picture is documented in the USAID funded BRIDGES project's (1987-88) research findings: "Teachers are poorly paid and often poorly motivated. ... Though teachers usually have 10 years of general academic training, a good number do not have pre-service training, especially in Balochistan where all teachers are hired directly as untrained teachers" (Rugh, Malik and Farooq 1991, p. 8). Other issues in teacher education include quantity (low pay and lack of status makes teaching the last choice of young men and women in urban areas) and deployment and supervision (teachers typically do not want to serve in rural areas). Research has also revealed no observable differences in the learning outcomes of students taught by trained and untrained primary teachers because of poor training. However, the number of years of formal schooling was found to be a far more significant variable in student's academic performance (ibid, p. 8). Warwick and Reimers (1995, p. 143) have also reported "that the general education of teachers proves to be a far better predictor of a student's mathematics and science achievement than professional certification at teacher-training institutes."

Throughout Pakistan, science is taught as a compulsory subject in classes one to ten. The Government of Pakistan Education Policy (1970) document states: "It is imperative

[1] Circular is a one page memo

that science education should commence from the earliest stage of education to develop a scientific attitude by stimulating, sustaining and rewarding the spirit of inquiry and the power to analyze and solve problems." The National Science Curriculum imposed by the centralized Curriculum Wing is the same in the four provinces (Punjab, Sindh, NWFP, Balochistan), the federally administered areas, and the Northern Areas and is inadequate to address the modern needs of the country. The curriculum includes fundamental science concepts, vis-à-vis living things, non-living things, matter, energy, forces, light, sound, electricity, and magnetism. It is intended to follow a spiral approach (more abstract concepts to be taught in upper grades). Analyzing the elementary science curriculum, Sheikh (1977) comments "sequential order of the concepts is parallel to the Piagetian stages of mental development. The teaching methodology recommended in the curriculum and elaborated in the teachers' guides is the discovery approach" (p. 7). Reflecting on science curricula and prevalent teaching practices in Pakistan, Iqbal (1994) remarks:

> Resultantly the teachers were not made familiar with the new approach and methodology envisaged in the new curricula ... emphasized the content and the product of science instead of the processes of science. As a result, experimental work was hardly made part of science teaching (p. 37). ... Until recent past, didactic method of teaching, lack of audio-visual-aids, lack of laboratories, incompetent and unmotivated teachers, poor quality of text-book, emphasis on factual materials and rote memorization, an ineffective system of examination and evaluation and above all, the lowest financial allocation to education have been the major weakness of science education in Pakistan. (p. 34)

In a report presented to the President of Pakistan, the Chairman of Federal Public Service Commission (1994) states:

> Teaching of many subjects in the country is sub standard and unless this unhealthy trend is arrested it may soon reach the nadir of educational incompetence. There is the same reliance on crib books and rote learning as before in preference to an in-depth study or comprehension of the subjects and there is no real quest for knowledge." (The Dawn, January 22, 1994, p. 4)

The National Education Policy Document (1998, p. 40) also considers the thinking development aspect of learning as an important issue to be addressed. It further suggests ways of achieving this:

- Focus on learner-oriented rather than teacher-centered (with the learner, i.e. the child, at the center of the learning process)
- Active learning, development of critical thinking, and creativity.

- Using highly interactive, learner-centered teaching and training materials.
- Integrating pedagogy with content knowledge.

The extent to which these recommendations and ideas regarding the teaching of science are practiced in the classrooms is questionable. Among other factors contributing to the low quality of teaching science, I have observed that in Pakistan teachers lack awareness of, as well as the skills to implement various teaching approaches. This results in the dominance of a memorization approach to science education, or what Blades (2001) calls a 'Bulimic' approach. The teaching/learning scenario is well described by one of the M.Ed. course participants at the Institute for Educational Development:

> Reflecting on my own experiences as learner, I remember that the teaching/learning of science at all levels of education in Pakistan is 'teacher dominated.' A teacher's main practice in the science classroom is to 'transmit' the prescribed content. Students accept the externally imposed definition of scientific phenomena based on the authority of the teacher and the textbooks. Looking back at the situation in which I have learned science, I clearly remember that we spent many hours and days memorizing scientific concepts from the textbook just to pass the examination. In this teaching-learning culture, I found science 'boring' 'useless' and unrelated to everyday life.
>
> As a beginning science teacher in the early 1990's, I taught science to my pupils exactly the way I was taught. Mostly I used the exposition method. This traditional approach of teaching of science is still dominant in Pakistani science classrooms. Various sources revealed that in Pakistan, science teaching in the primary, middle and secondary level is done generally using a transmission mode of teaching. (Journal entry, June 1995, used with permission)

For most science students in Pakistan, the content for a class is found within the covers of a single textbook. The textbooks comprise a never-ending list of often-unconnected facts on the topics. For example, a grade eight equivalent textbook with 83 pages covers 13 chapters and contains 13 topics (about 6 pages per chapter): structure of living things; cells and organisms; elements, mixtures and compounds; solutions, acids and bases; oxygen and carbon dioxide; heat energy; light; current electricity; sound; Earth; revolution of satellites, planets, comets, meteors, stars and galaxies; and mineral resources of Pakistan. Questions at the end of each chapter range from three to six in number and require recall, short answer response, or fill in the blanks. This book, prescribed by the Curriculum Wing, is the main source of science information. This is the case with all other grades as well. The authority reverts from the teacher to the textbook. Most of the facts are unrelated to students' lives. Issues that are affecting them because of their controversial nature are avoided altogether.

A select body of facts is taught to students through the lecture/textbook method. Having worked as a teacher educator in Pakistan for the past six years and having observed science teachers teach lessons during these years, I have found that the most common teaching technique observed in the schools is teachers asking students a few questions so that they would be able to name the topic to be taught in class. The teacher then calls upon students to read, stopping at the end of a paragraph or two to explain what has been read. This is usually followed by the teacher giving a lecture on a topic for most of the 30 to 40 minutes allocated to science and asking students a few comprehension and recall questions towards the end. The way the subject science is presently taught exemplifies science as a fixed body of knowledge, which can be transmitted via the teachers into the many 'empty vessels' in the classroom. This resonates with Freire's (1973) banking concept, "... students are the depositories and the teacher is the depositor" (p. 45). He further explains, "In the banking concept of education, knowledge is a gift bestowed by those who consider themselves knowledgeable upon those whom they consider to know nothing" (p. 46).

Teachers usually administer a paper and pencil test to students at the end of each chapter, at mid-term, and at the end of the year. Tests comprise a few 'fill in the blanks' and recall questions. In the secondary classes (6-10), essay type questions are added which require students to write two to three page answers, in more or less the same words as in the textbook.

Like schools the world over, Pakistani schools are also being pushed into serving the economy. Science, technology, and English are emphasized. While most schools would search for the best qualified teacher to teach mathematics, science, or English at the secondary level, there is a commonly held belief that anybody can teach science at the primary level. Sheikh (1977) explains about primary science teaching as:

> In the primary school science is taught by the general classroom teacher and there are more than hundred thousand such teachers. *Most of these teachers have done 10 years of schooling with one year of professional training.* At school they have done either a two years course in 'general science' or two years of physics, chemistry and biology. At the one-year of professional course these teachers are prepared for the teaching of all the primary school subjects, thus they have little time for a good grounding in subject matter and teaching methodology of science. (emphasis is mine, p. 8)

Warwick and Reimers (1995) explain and describe primary education as:

> The country's best students, particularly men, often see primary-school teaching as their last choice of professions. Those who do become teachers are faced with a negative image in the society; lower wages than those given to unskilled laborers; few other benefits; poor preservice training; and in-service training that does not affect how they teach or what their students learn. The methods of instruction teachers use in the classroom, particularly rote memorization, lead students to repeat material from lectures and textbooks rather than develop a thoughtful understanding of the subjects they study. (p. 139)

PERSONAL PERSPECTIVE OF THE RESEARCH

Growing as a Science Educator

My experiences of teacher education started in the 1970s at the Kenya Science Teachers' College, Nairobi, Kenya. I was then teaching both academic (science, physics in particular) and professional (classroom teaching practices and methods specific to science) courses to pre-service teachers after their completion of an equivalent of Grade 10 at the secondary level. These students were aspiring to become teachers at the secondary level. I was a full time faculty member at the college and was required to work closely with the Department of Education at the college that was responsible for teaching psychology, history, sociology, and general methodology of education. Though I would try to link theory with my own practice, I never really understood how the science pedagogy fitted into the larger domain of education. I enjoyed learning and teaching science. I was good at it. I planned my lessons in advance and I thought I taught well because my students liked my classes and did well on their written exams. When I followed the students teaching in the classrooms during their practicum, to my surprise many of the student teachers had problems. I often wondered why. However, I never went beyond that to question or probe the teachers to inquire into my practice, the relevance of the course work, or the relation between theory and practice.

In the early 80s, my family and I migrated to Canada in search of a better future for our children. I aspired to continue teaching as a career and, with support from my family, ventured to the University of Alberta in 1982/83 to pursue a BEd. Though this experience still reflected the traditional 'application-of-theory' model, it was refreshing and enriching in terms of classroom practice. The support from my supervisors and cooperating teachers eased me into the Canadian school culture earlier than I would have otherwise expected. This strengthened my belief that to socialize, interaction in the appropriate cultural context is crucial.

In the 80s, I had two more personal and professional growth opportunities at the Red Deer College, Red Deer, Alberta, Canada. One was teaching academic courses (upgrading and first year physics university transfer), and the other was team teaching with and mentoring an enthusiastic novice (pseudonym Bill) teacher to help prepare him to teach first year university physics. I was inspired, stimulated, and challenged to teach the upgrading courses in mathematics, physics, and chemistry to mature, adult students who had returned to school after being out in the work force. Unlike the Kenya Science Teachers' College student teachers, the Red Deer College students were more focused, intrinsically motivated and had a strong desire to learn to do well in the subject areas and to get good grades. I believe this was because the Kenya Science College teachers were fresh out of high school, had no work experience, and were still seeking direction. The students at Red Deer College, however, had practical experience which cultivated within them a strong sense of intrinsic motivation, commitment, and purpose. This experience reinforced my belief that motivation plays a significant role in learner development, be it as a teacher or as a student. Intrinsic motivation combined with willingness on the part of the learner to accept me as a mentor were once again greatly responsible for my success in team teaching and mentoring the novice teacher. This being my first field-based teacher development assignment, I developed a strategic working plan in consultation with the faculty from the Red Deer College Department of Education and shared it with Bill. Our model was for Bill to:

- Examine his teaching (supported and probed by me)
- Read some articles and reflect upon them to identify what matched with his practice
- Plan his teaching, incorporating learnings from discussions or readings.
- Implement the plan and reflect upon it.

Bill was also encouraged to observe other department colleagues' lessons. The goal was to facilitate Bill's professional growth in a supportive and natural setting. This experience helped me to reflect on my own teaching and teaching in general.

I enjoyed the process, although now when I reflect upon it, I have come to believe that, for the most part, I was mostly operating at the technical level; it was often my ideas that I expected Bill to implement and report. It worked in getting Bill to face with

confidence and competence college classroom realities that strongly emphasized content knowledge and grades. Bill emerged a liked and committed teacher, ready to carry on. At around this time my husband took up a contract overseas to work in Pakistan. I moved with him to Karachi, Pakistan and eventually into the site of teacher education at the Aga Khan University Institute for Educational Development.

My Field-Based Teacher Education Experiences

The Aga Khan University Institute for Educational Development (AKU-IED) is a non-government, not-for-profit-organization in collaboration with the Pakistan Government that has a vision to be instrumental in education reform and improvement in Pakistan. This institute, since its start in 1994, offers a variety of in-service teacher development courses: an MEd, a Visiting Teacher Program, an eight week long refresher course, and a Subject Specialist Teachers Program which is a one year diploma course in five areas (Math, Science, English, Social Studies and Primary Education; Visiting Teacher Program is a prerequisite for this program). I have been a member of the faculty at this institute since 1994, initially on a part-time basis, and currently on a full-time basis. I have had the opportunity to play the role of facilitator or teacher educator in programmatic activities or courses offered. The programs that proved most significant to me were the Subject Specialist Teachers programs (in Math and Science). These emerged as a consequence of the learnings from the initial Institute for Educational Development programs caused concern about teachers' subject knowledge as revealed during their implementation of new innovations. These programs were offered in 1997/98 separately, but concurrently. Each of these programs was designed as a one year, field-based model for the participants' professional and academic development. The emphasis was on content, but the pedagogical aspects were also interwoven appropriately. Most of the program took place in the participants' home schools, consistent with current concepts of field-based model of teacher preparation (Korthagen and Kessels, 1999). I had central leadership roles (coordinator, facilitator, and mentor) to implement the programs for the first time. The distinguishing feature of the Subject Specialist Teachers Program was reflecting upon practice through 'success' stories shared by teachers. These helped the participating teachers to develop confidence to 'voice'

their contextual needs and realities in a non-threatening environment. In addition, it helped them to develop a personal conceptual understanding about classroom practice by reflecting on their own and their colleagues' stories. The participants' stories acted as a powerful source for identifying themes in the dynamic process of teaching and learning. The teachers' observations (gathered during group sessions and course end evaluation), of the process, that follow are testimony to this (Pardhan, 1998):

> I also observed that many weak students were able to complete their work in the given time, which was a good achievement.
>
> Science teaching and learning can become very interesting if science teachers give demonstrations and then involve students in performing experiments, which can then lead to better understanding and retention of different topics.
>
> There was a change in my teaching after attending this programme. I realized that now I can give the students better teaching and better ways of conceptual understanding. It was also noted by me that students were taking a keen interest in the activities.

Initially, the teachers demonstrated reluctance and anxiety when it was time to share their narratives. However, with the passage of time, they exhibited interest in writing and reflecting upon their experiences, as well as talking about them for the purposes of insightful learning. The more the teachers reflected upon their practice, the more interested they became in understanding teaching as a personal endeavor and not as an exercise imposed upon them, and the more they got engaged in curriculum development. For me all these were fascinating lived experiences in which to appreciate and recognize the complexities of the demands and challenges faced by the teachers. This awakened a strong desire in me to further explore science teachers' development in a contextual setting.

My lived experiences of the Kenya Science Teachers College, the Red Deer College, and the Institute for Educational Development have motivated me to undertake this commitment to explore and examine more closely my notions about teachers' professional development through the rigors of a research study.

My new attitude, at a truly conscious level, to the relationship of science pedagogy and education started at the Institute for Educational Development, where I had the opportunity to work collaboratively with highly experienced faculty in the field from Oxford University, England, Brock University, Canada, and University of Alberta,

Canada. I was exposed to many innovative, contemporary ideas in science education and science pedagogy in particular, such as constructivism. I was inspired and enthused to implement constructivist ideas and approaches to the teaching and learning of science to different groups of student teachers. Observing them in the classroom spaces working with children, I often noticed problems such as class control, resource management, selection of appropriate activities and tasks for the level taught, gaps in content knowledge, managing student-questions, discussions and managing time. I wondered why students would lack science knowledge and could not teach well. I was beginning to appreciate the importance of teachers' confidence in their content knowledge and their ability to transform the content into a meaningful and effective way so as to minimize classroom problems and optimize student learning; in Shulman's (1987) words, the teachers' pedagogical content knowledge. I would engage in helping the teachers, but did not feel fully satisfied with my understanding about the connections between subject matter knowledge and the teachers' pedagogical knowledge. As I lived my experience through my EdD program, I decided to continue to focus my research on the area of science teacher education and, more specifically, to explore viable ways of enhancing science teachers' subject matter knowledge, pedagogical knowledge, and the intersection of the two.

My Grad Experiences

Although I had joined this program with a diverse, multicultural theoretical perspective, as described above, and a research question in mind, as I began writing my proposal and reformulating my research question, I was intrigued to discover that I was questioning my own practice and, in fact, that I had been doing this for a long time. The more I read and discussed in Action Research course sessions, the more this insight became clear to me. I started recognizing and realizing that all this time I had been troubled with the whole notion of science education pedagogy and critical thinking resting not just with the teacher educator, but more so in the practice of the participating teachers. I intended to bring about a further change in my thinking to develop a better understanding of teacher development by adopting a critical perspective of Action Research. This compelled me to locate my research in the area of action research.

My Interest Area

My study focused on the question of how science teachers' pedagogical content knowledge can be enhanced in a way that will prepare them to develop knowledge, skills and attitudes to promote science education. To begin this project, I intended to have a better understanding of the experience of science pedagogy in the context of teacher education. For this, I specifically intended to elaborate on the different perspectives of the practices of science pedagogy in teacher education and to identify possible ways that concerned teacher educators can rethink these practices. I also intended to situate myself in the area of science education. I had three main reasons for choosing science teacher education as a context for my research. First and foremost my development as a science teacher for the past thirty years has moved through paradigm shifts: subject-matter mastery; subject matter followed by teacher certification; traditional theory into practice; and field-based models that integrate subject matter and pedagogy. It is only recently that I have come to appreciate the importance of teacher confidence and competence in both subject matter knowledge and pedagogical content knowledge for good classroom practice. I started my teaching career with a strong subject matter knowledge and an interest for teaching and I performed well. I had many colleagues without any teacher education. They were also performing well, at least our school ranked high in student achievements. These indicators made me believe that what counted most to being a good teacher was subject matter knowledge. Secondly, my several years of experiences in teaching, teacher education, and having read various materials about current trends in teaching and learning have convinced me about the importance of pedagogy in the teaching and learning process. Last but not least, I have also realized that science and math pedagogy is a neglected domain in Pakistan; thus this provided me with an appropriate site for inquiry to make a difference.

Chapter 2

THEORETICAL FRAMEWORK

SCIENCE PEDAGOGY IN TEACHER EDUCATION

Earlier I mentioned my experiences of teacher education and described how I initially envisaged subject matter as unrelated to the pedagogy. I have come to realize through these experiences the complex and dynamic nature of the process of learning to teach. I once believed that knowing subject matter and having an interest in teaching is enough to be an effective teacher. Today I have a different belief. I agree with Kauchak and Eggen (1993) when they say, "becoming an expert teacher is a complex, multifaceted process ... it also requires several different kinds of knowledge ... we cannot teach what we don't understand" (p. 13-14). They further comment that this is well documented by Shulman's research (1987) on the relationship between what teachers know and how they teach.

I am a product of the traditional approach of professional development. I recall some of the turbulent learning experiences I encountered during my professional development. Many of my memories are of rote learning, coercion, and paper and pencil evaluation. For the most part I sat in classrooms where 'legitimate' knowledge was delivered through cultural transmission. Apple (1993) calls this knowledge 'official knowledge,' knowledge that is stored and represented through official textbooks. He further defines an official textbook as a book designed for an authoritative version of knowledge, best known to the 'officials' themselves, that is passed on to others through prescribed pedagogy. These books are first imposed on teachers by government or employees of the teachers and the teachers in turn impose them on students. This practice still exists in most developing countries including Pakistan. The observation on page five of this thesis from a report presented to the president of Pakistan by the chairman of Federal Service Commission (1994) supports this. This is not surprising because Kizilbash (1998) expresses the following concern about public teacher education courses in Pakistan:

> The courses have been described by students as only vaguely relevant to the work they have to do in school, and the use of the lecture method seems to be in universal use in colleges of education. (Quoted in Hoodbhoy, 1998, p. 110)

Osaki (1990) has made similar observations about teacher education courses in East African Universities where teacher education also receives little attention. University educators who usually coordinate the process have faced several problems including conflicts between the academic content requirements in teacher education and the professional aspects. Some of the educators in authority have perpetuated the problem by arguing that if the student knows the subject content of the disciplines (i.e. science, math), then there is no need for him/her to go through the teaching/learning processes and classroom techniques (Osaki, 1990, p. 36). Whether in Pakistan or East Africa, educators like Kisilbash and Osaki have brought to attention that student teachers face several obstacles to developing pedagogical content knowledge. Osaki (1990) comments that:

> Student-teachers face several problems in classroom presentation, ranging from inability to arouse student interest, failure to explain things properly, lack of effective questioning strategies, and inability to organize student activities be they group discussions, debates, or laboratory investigations. These are observed even among second year students who have done Teaching Methods Courses. (p. 40)

Thus there exists tension at the sites of teacher education. Goodlad (1990, cited in Korthagen and Kessels, 1999) explains this tension as a result of a lack of adequate integration of pedagogy and content in methods courses at the teacher education sites. For him the two components, pedagogy and content, are intertwined to harness one another.

Two contrasting perspectives on teacher preparation have been advocated: the first one is a stage theory or single development stage in teacher education (Kagan, 1992); the second theory conceptualizes the simultaneous development of all dimensions i.e. the blending of content, pedagogy, management skills and student understanding (Vonk, 1995; Grossman, 1992).

Stage theory is a dominant perspective. This perspective maintains that novice or untrained teachers must first concern themselves with matters related to survival and management skills and then move on to concerns about teaching specific subject matter. Kagan's model is a result of her review of literature on learning to teach. She argues that teachers need to first focus on competence in management and instructional routines to be able to then reflect upon teaching of content and ethical issues.

Grossman critiques Kagan's model and her selection of studies used for supporting her model. She supports her three critical concerns with other findings. First, the studies by Grossman and Richert (1988) on the knowledge growth of teachers have revealed that student teachers do concern themselves with issues of content teaching concurrent with survival skills and ethical matters. She further argues that it is a question of what method is used for data collection to influence teachers' reflections on different dimensions. For her, teachers are likely to reflect on 'self' in their personal journals. In addition, the model does not take into consideration the impact of course work on teachers' growth. Studies by Ball (1988) and by Grossman (1990) cited in Ball and Wilson (1996) have shown evidence that course work can help professional development of teachers. Lastly, Grossman argues that Kagan's model is simplistic, neutral, and unproblematic. It isolates the classroom control from teaching/learning by assuming that teachers first establish control and then attend to students learning content; whereas, for Grossman, control and teaching/learning are interwoven to achieve the best student outcomes.

The insightful arguments of Grossman provide an alternate vision for the professional development of pre-service teachers. She argues that the teachers right from the early stages need to be concerned with their pedagogical content knowledge, what she calls the "understanding of subject matter, or the development of pedagogical thinking" (p. 172), so as to avoid running the risk of encouraging technical thinking. Research-based theories outlined by Grossman of teachers learning how to teach also favor teachers' growth in their understanding of subject matter as a starting point with the belief that "thinking about the teaching of subject matter can influence what teachers will later learn from classroom practice" (p. 176). This perspective has, undoubtedly, made positive contributions. However, I feel this has some underlying assumptions that may make it problematic for the perspective to achieve the desired goals. There is a possible risk that while trying to address the notion of content knowledge, pedagogical content knowledge, by default, may take the form of stage theory.

The two most talked about perspectives that exist in the literature on learning to teach in general and science/math in particular may be categorized as discipline-oriented (or content-oriented or subject matter-oriented) and constructivism or student-oriented.

A Discipline-Oriented Perspective

The discipline-oriented perspective is associated with the works of professor Lee Shulman of Stanford on Pedagogical Content Knowledge (PCK). For Shulman (1987),

> successful teachers cannot have only an intuitive or personal understanding of a particular concept, or theory. Rather, in order to foster understanding, they must themselves understand ways of representing the concepts for students. (p. 12)

Shulman's pedagogical content knowledge is a blending of content and pedagogy into an understanding of how particular topics or issues are organized and represented in a meaningful way for instruction. Wilson, Shulman and Richert (1987) suggest that the teaching process blends pedagogy and content. The resulting model presents a cyclic process (see Appendix 4). This process starts with the teacher's comprehension of the content, followed by the teacher transforming the content in a representation appropriate for students, instructing, evaluating, reflecting, and entering a new comprehension level and another teaching/learning cycle at a higher level of understanding and performance. For Shulman, the comprehension of content/purpose is important for the teacher as well as for the non-teaching others. However, the difference lies at the intersection of the content and pedagogy in the knowledge base of teaching, in the capacity of the teacher to transform 'personal' content knowledge into representations that are pedagogically sound and that cater for the varied abilities, interests and backgrounds of the students.

Anderson (1989) expresses his concern with pedagogical content knowledge by posing two important questions in the interest of prospective teacher educators. *What* exactly do the teachers need to know about the subject, and *how* will they use that knowledge? Anderson observes that Shulman, Wilson and Richert's model helps to address the 'how' question, but not the 'what' question. The 'what' involves the nature of the science/math knowledge and what teachers need to know to carry out the transformation of this. Anderson proposes three aspects of subject knowledge for effective teaching: structure, functions, and development. The structure of science/math refers to relationships amongst the facts, concepts and procedures of the science disciplines. Some possible questions one may ask are: What are important themes and how do they link or interrelate? How do ideas from one discipline relate to the ideas of another discipline? For example, a problem on motion can be solved in many different

ways: graphically, using diagrams, experimentally, or using algebraic equations to name a few.

The functions/purposes of knowledge are the activities/tasks that the teacher prepares, with the knowledge of the discipline for learners to accomplish: What will the students do to learn? Will they listen, observe, or investigate? Is what the students are to learn appropriate? The important question Anderson discusses is: "What can we do with the disciplinary knowledge to enable students to see relationships between the discipline and the rest of the world?" That is, how can we relate disciplinary knowledge to events in students' daily lives, issues students may confront as citizens or workers, and to other disciplines?

The development of subject knowledge may be considered as an alternate means to teaching understanding. These means should not be to teach a discipline in a fragmented way or to give students lists of isolated topics to memorize; instead they ought to be taught in a holistic way. Cited in Anderson, Toulmin (1972) suggests that the scientific concepts need to develop like an organic evolution of organisms in an ecosystem and he portrays:

> the concepts of a discipline as drawing their full meaning and vitality only from the network of interrelationships that ties them together. But like an ecosystem, the discipline is always changing. Old concepts evolve into new ones, or new concepts, sometimes imported from other disciplines, compete with the concepts that were there before and alter patterns of relationships. (p. 97)

The present body of science discipline is rooted in its historical development and is evolutionary in nature. It is never fixed and fragmented. It has evolved through human activity and has been constructed by human beings. Posner, Strike, Hewson and Gertzog (1982, cited in Anderson, 1989) remark that individuals construct and develop disciplinary knowledge in the manner suggested by Toulmin. Learners thus, instead of just absorbing knowledge, construct it through a complex process. This process puts demands on teachers' understanding of the students as well as knowing their subject matter knowledge for them to be able to teach for development of subject knowledge.

A discipline-oriented perspective assumes that a body of knowledge is 'out there' and which a learner can get and understand. It seems to assume that knowledge is unproblematic/neutral and has not much to do with the individual learner. However,

Shulman (1986) suggests student teachers or teachers should learn how to transform content knowledge into pedagogical content knowledge. Anderson (1989) has noticed this is problematic for students. The problems arise because teaching for pedagogical content knowledge or what Anderson calls disciplinary knowledge of a school subject matter like science places special demands on teachers' understanding of structure, function, and development of knowledge in the discipline and that in turn calls for an understanding of the learners. The vignettes in Anderson's discussions revealed that for transformation of knowledge of subject matter, for meaningful learning, the disciplinary knowledge plays an important role.

A teacher working within a discipline-oriented perspective focuses heavily on lesson preparation rather than on actual classroom practice/realities. This can be interpreted as a teacher prepares to transmit the knowledge so it is 'managed.' Implicit in this model is that any kind of reaction from students can be considered as a constraint to the delivery of instruction. This may easily situate this learning view in the stage theory paradigm. Anderson's arguments about pedagogical content knowledge suggest the model is placing a strong emphasis on the content of the discipline.

A Constructivist Perspective

In sharp contrast with discipline-oriented perspective on learning to teach is a contemporary theory of learning called constructivism. Pioneers in constructivism such as Cobb and Steffe (1983), Driver (1989), and Scott (1987) offer yet a different perspective in the space of professional development of teachers' content and pedagogical knowledge. They maintain that teachers' pedagogical content knowledge should be grounded in what is known about how children construct scientific and mathematical ideas:

> Learning outcomes depend not only on the learning environment but on what the learner already knows: Students' conceptions, purposes and motivations influence the way they interact with learning materials in various ways.
> (Driver and Bell, 1986, p. 444)

This view emphasizes the importance of the psychological and experiential domain in learning rather than just the content. The teachers are thus expected to construct viable perspectives about children's learning of science based on insights provided by teacher

educators that are informed by research findings on how children learn. The last 15 to 20 years have seen a remarkable change in the 'thinking' about students' learning science/math. The shift is from rote/factual learning to conceptual understanding (Shulman, 1986). Why the change in emphasis?

It is predominantly because research findings from many countries have indicated that, despite many years (10 to 12) of formal schooling, students in many instances are not acquiring adequate scientific ideas about how to interpret their world. At the end of secondary school, large numbers of students still hold many ideas that do not match with the scientist's knowledge. This has troubled educators and extensive work is being done under the rubric of the 'Alternative Conceptions Movement (ACM).' This has raised the following concern: What does it mean to learn science/math? Currently, amongst the educators learning is viewed in part as a conceptual change. Even before formal schooling, children have constructed their own ideas and views about phenomena and happenings (that the literature calls children's knowledge or intuitive ideas) to interpret the world around them. As revealed by the works of the researchers mentioned above and many others (Appleton and Asoko, 1996; Driver, Guesne and Tiberghien, 1985; Driver and Oldham, 1986 to name a few more), children's ideas are often at variance with the scientific views generally accepted by the public (also called public knowledge or scientific views). For students then to learn school science means to change their beginning ideas in light of scientific views to make better sense of the world they live in. It is also hoped that they learn to appreciate scientists' science and its nature.

The need to reconceptualize the meaning of 'learning science and math' is a central concern. Northfield (1991: cited in Skamp, 1998) has extended this realization to teacher education. Kagan (1992) documents that just as many students do not change their ideas about how their world works through formal schooling, some pre-service science teachers at the end of their teacher education do not change their views about learning and teaching. This contradicts the view that knowledge is 'out there,' but supports the view that learning is embodied in and through the learner. Teacher development assumes the possibility of changing teachers' already held beliefs/notions about teaching/learning. Thus learning is seen as a process of conceptual change. An appropriate starting point to affect change would be first to identify the existing ideas of

the teachers and then engage teachers in tasks to help them bridge the gap by questioning their own practices. This is the premise of constructivism, which maintains that knowledge is generated through a cyclic/spiral process when the onus is on the individual to take responsibility for learning. Today research on *how* learners learn favors a 'constructive' position (Cobb and Steffe, 1983; Driver, 1989; Scott, 1987).

There are a number of projects and movements in science/math education that support the notion of constructivism. Some more famous ones are: the Project to Enhance Effective Learning (PEEL, 1986) from Australia; the Children's Learning in Science (CLIS, 1986) Project in England; and the Students' Intuitions and Scientific Instruction (SI, 1987) Project United States. These kinds of projects are predominantly in response to the new reforms in National Curriculum in Australia, the UK, and the USA. In the light of new 'standards' set by new curricula, the role of teacher education is to enable teachers to choose worthwhile tasks; to orchestrate classroom discourse; to create a learning environment that emphasizes problem solving, communication, and reasoning; and to develop the ability to reflect on actions, i.e. for teachers to analyze their teaching and learning.

Fennema and Franke's (1992) Cognitively Guided Instruction (CGI) project in the area of mathematics education considered the question of whether teachers can better facilitate student learning when they are knowledgeable about how students learn mathematics. They endorsed the idea that children's ideas/thinking, when appropriately integrated in sound manner and made part of the curriculum, can influence the teaching and learning of mathematics. This model implies that the teacher's conceptual understanding and cognition is crucial to student learning. The implication for the education of teachers is to recognize teachers as 'thinking selves' who can internalize and utilize the knowledge about how students learn in constructing their own/individual instructional discourse.

The constructivist paradigm of teaching and learning has been very useful in bringing to the surface the complex nature of the process of learning to teach. Teaching is a complex cognitive activity. It is not a linear, technical process with simple predictable outcomes. What makes it complex and challenging is that it is unpredictable, multidimensional, and calls for simultaneity and spontaneity. It emphasizes the central

role of students' understanding of science constructs. This places special demands on teachers. Extensive research on constructivism has brought a realization that it is not only students that construct ideas, but teachers construct ideas as well. This means that teachers must also construct ideas on the teaching of science and the process of science education.

Constructivist perspectives offer insightful and challenging suggestions for empowerment in science teacher education. However, its complex nature opens up possibilities for tensions in implementing it or some of its ideas. Recently, I was observing a science lesson of an in-service student teacher trying to use a constructivist idea in a science class. The teacher was trying to get students to conceptualize 'melting,' in terms of particulate nature of matter. What does melting mean? What might be happening to the particles during melting? Students were provided with ice-cubes to observe it melt and then they engaged in a conversation with the teacher:

T: What do you think might be happening to the particles during melting?
S: Miss, the particles gain energy from the surrounding.
T: How? Can you elaborate it?
S: Heat energy of the particles of ice is lower than the particles of the air in the room. Therefore, heat is transferred to the ice.
T: What does heat energy do during melting?
S: (looking at the particle diagram) I think because of getting heat energy, the kinetic energy of the molecules increased and they started moving fast and changed into liquid.
T: Are you saying that kinetic energy of the particles increases during melting?
S: Yes Miss.
T: Good. (Field notes, April 1999, used with permission)

Later, in my conversation with the teacher, I challenged the teacher about the change in kinetic energy during melting: (Key: C represents me and T represents the teacher)

C: Can you tell me what happens to temperature of ice cubes during melting?
T: It stays at zero.
C: What does that mean?
T: Em… it doesn't change.
C: It doesn't change … tell me more…
T: Yes, it will be the same and …
C: Go on; tell me more about ice melting.
T: There will be ice and also water.
C: What about temperature?

T: Same but now particles (looks at field notes) moving… moving… Oh my God… particles moving fast… no.
C: Go on.
T: If temperature is the same, then particles… cannot be moving fast.
C: Particles cannot be moving fast…
T: I mean faster.
C: You mean faster
(Teacher looks at notes again)
T: Yes and the temperature will not change. Yes (suddenly surprised)… the kinetic energy will be same … (as if embarrassed) … Oh! My God I told students it will increase. What do I do now? (Field notes, April 1999, used with permission)

The teacher was attempting to help students construct knowledge while personally still grappling with her own content knowledge. In the process the teacher introduced a misconception to the students "during melting kinetic energy of particles increases." The teacher had the students redo the activity the following day, this time using thermometers to monitor the temperature of the melting ice as well and then to rethink to make a plausible explanation; the teacher was not fully satisfied, however, because some of the students still switched back to the previous days' thinking. A journal entry by this teacher speaks about the tension in implementing constructivist ideas:

> *At times during a lesson when confronted with a question I would get stuck and would not know how to answer the question or give a satisfactory explanation.* Once, while students were discussing the particle being the smallest 'unit' of matter, one student argued "… but I have read that a particle (atom) consists of electrons, protons and neutrons. So how can a particle itself be the smallest part of the matter?" At that moment I felt myself blank and did not know how to respond to the student. *I knew a lot about the individual concepts but I could not link them to help my students to understand what 'unit' meant. As a student I learnt science mainly through traditional approach: this is why I think I am facing problems.* My lack of content knowledge is also affecting my pedagogical skills. (Journal entry of student teacher, 1999. Emphasis mine. Used with permission)

Undoubtedly, the students' lived experiences have given deep insight into the complex realities of an innovation like constructivism. Nilssen (1995) and Borko et al. (1992) have also cited examples from the knowledge domain of mathematics about student teachers that after several attempts in trying to rectify a situation analogous to my teacher lost control and gave up in favor of conventional methods.

The immediate reaction to the above-described problems could easily be associated with the student teacher's lack of pedagogical content knowledge. A closer look at it would rather situate the problem right inside the very practice of constructivism. In this

practice the teachers are required to understand how students think and to value students' ideas. Concurrently, teachers are to respect the 'concepts' of the discipline of science. The teachers have a challenging job of negotiating the science concepts of the scientists with the students' concepts. When the two are at variance, the student teacher enters into a problematic zone and seeks a safer ground; that is, the traditional method. This perpetuates the survival and self-concern model. A way out of this is for teachers to have pedagogical content knowledge that integrates the content and pedagogy appropriately and carefully.

Pedagogical Content Knowledge

Discipline-oriented and constructivism are two perspectives that are integral parts of a teacher's knowledge base, the pedagogical content knowledge, for the teaching and learning process. This term was first introduced by Shulman (1986). He offered a theoretical framework to describe a teacher thinking domain called content knowledge in teaching. The content knowledge in teaching according to Shulman encompasses three categories: subject matter content knowledge; pedagogical content knowledge; and curricular knowledge. Shulman's description of subject matter content knowledge is, "the amount and organization of knowledge per se in the mind of the teacher ... [that] requires going beyond the facts and concepts of a domain" (Shulman 1986, p. 9). It constitutes the ways in which concepts and principles of a discipline are organized within a discipline as well as how the truths and falsehoods are established. For Shulman, a teacher must "understand why a given topic is particularly central to a discipline whereas another may be peripheral" (p. 9). Pedagogical content knowledge is how the subject matter content knowledge is represented: "the ways of representing and formulating the subject that make it comprehensible to others" (Shulman 1986, p. 9) and knowing which instructional approaches and strategies will facilitate student learning of the particular topic/s. He explains this construct in the following words:

> Teachers must not only be capable of defining for students the accepted truths in a domain. They must also be able to explain why particular proposition is deemed warranted, why it is worth knowing, and how it relates to other propositions, both within the discipline and without, both in theory and practice. (p. 9)

According to Shulman, curricular knowledge is a teacher's:

> understanding about curricular alternatives available for instruction ... ability to relate the content of a given course of lesson to topics or issues being discussed simultaneously in other classes ... familiarity with the topics and issues that have been and will be taught in the same subject area. (p. 10)

Shulman goes beyond the content knowledge to the aspect of transforming the subject matter knowledge to make it comprehensible to others. He defines this as the pedagogical content knowledge and suggests that it is the form of content knowledge that "embodies the aspects of content most germane to its teachability" (p. 9). Pedagogical content knowledge encompasses knowing the most 'meaningful' and 'powerful' ways of representation of subject matter and understanding what makes learning easy or difficult for students. Thus pedagogical content knowledge can be conceptualized as a blending of pedagogy and content in such a way as to translate or transform content into curriculum. This idea of Shulman has important implications with regards to the role of teachers. Carre and Ovens (1995) have articulated it as "a teacher's role emerges from an understanding of both subject knowledge and the ways children learn" (p. 5) ... they then go on to say that "individual teachers do not have one instructional approach all day long; the nature of the subject shapes the way a teacher teaches" (p. 5). Since the late 1980s, several studies have been reported on the importance of pedagogical content knowledge of science teachers. Smith and Neale (1989) studied the role of subject matter knowledge in primary science teaching and Appleton and Asoko (1996) documented a teacher's progress in transforming the constructivist view of learning in elementary science.

In retrospect the discipline-oriented and the constructivist perspectives of science education exhibit dilemmas and tensions. This calls for an alternate perspective that takes into account conceptual change within the epistemology of knowledge. The dilemma lies in the dichotomy inherent in the two perspectives, i.e., objective knowledge versus subjective-content knowledge. The discipline-oriented view ignores the context of classroom practice realities and assumes that the student teacher and the student are passive learners. On the other hand, constructivism introduces complexity and multiplicity by adding the context and active participation of the students to the discipline-oriented perspective without questioning the abstractness of knowledge. The question about the role of content knowledge still remains inadequately addressed. The

constructivists' argument for promoting teachers' and students' personal construction of knowledge need to be considered carefully and critically. Knowledge may be individually (von Glasersfeld, 1995) or socially constructed (Vygotsky, 1978). Knowledge may also be seen to co-emerge through human interaction with the others and the environment. Thus knowledge may exist only when it is enacted in the interaction (Varela et al., 1991).

Group discussions and interactions can thus provide sites for interactions and critical reflection on experiences and shared meanings. It seems logical to carry on the search for better learning/teaching models collectively with 'others.' That is to share our collective and personal learning to construct a contextual perspective. As I will discuss in the next chapter, this is the premise of action research that encourages change through collaborative action, with involvement of all participants, to empower teachers to develop their own theoretical perspective of good classroom practice by reflecting on their personal and collective experiences; thus to strive for shared meanings and understandings.

Chapter 3

MY STUDY AND METHODOLOGY

ACTION RESEARCH

Action research is a style of research which originated from the works of the German social psychologist Kurt Lewin (Adelman, 1993). Lewin was concerned about the gap between the theories on society and the dynamics of social practice to bring about changes. He introduced participatory procedures for solving problems and, in the process, popularized the tradition of action research. He put forward three important characteristics of modern action research: its participatory nature, its democratic pulse, and its simultaneous contribution to social science and social change (Carr and Kemmis, 1986, p. 163-164). Following Lewin, various manifestations of action research have developed. Action research subscribes to the belief that we may simultaneously inform and change ourselves and, thus, acquire a deeper understanding of the situation through our actions. Early education action research emerged from the "teacher as researcher" movement (Elliot, 1991; Kemmis & McTaggart, 1988). Today there are many other possible frameworks under the headings of action research including: constructivism, enactivism, post-modernism, and post-structuralism, just to name a few. Despite the wide range of approaches to action research and the differing theoretical underpinnings, all action research shares in common a systematic process of inquiry into practice.

Carr and Kemmis (1986) particularly emphasize the principle of equal and democratic involvement of all the participants at all stages of the action research process, with a hope that the sharing of lived experiences as a participant in the group will promote the professional practice of those who choose to be active participants. In my study it was anticipated that this professional development would manifest itself in constructive actions that would occur as discoveries unfold within the group through the spirals of planning, acting, reflecting, and repeating these cycles. Figure 3.1 'a representation of the Lewin action research model' (in Kemmis & McTaggart, 1988, p. 8) shows the key features of this cyclic process. These can be interpreted by practitioners or action researchers who identify problems for inquiry and who are required to formulate strategic planning through deliberations.

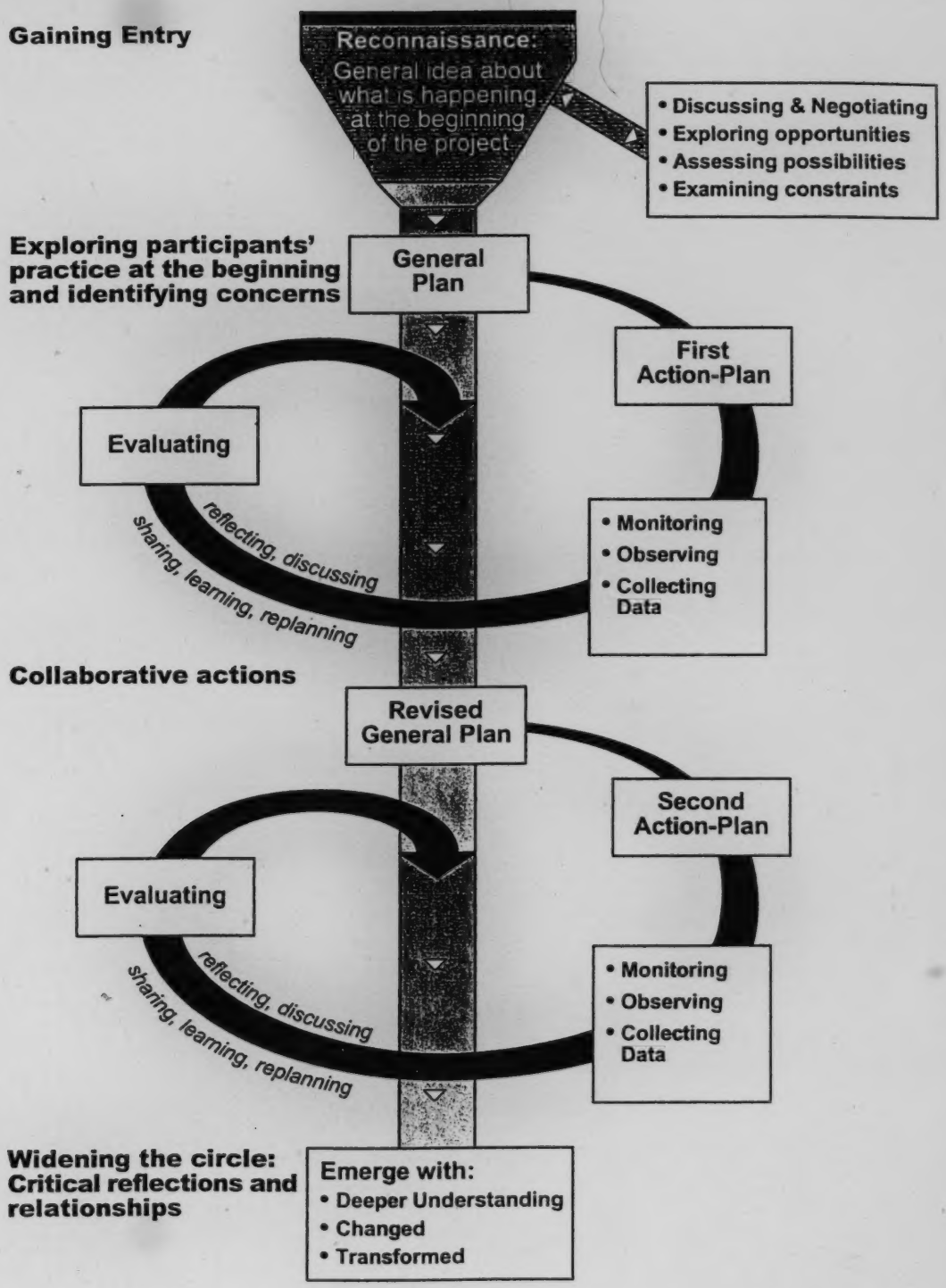


Fig. 3.1 A representation of the Lewin action research model (Kemmis & McTaggart, 1988, p. 8)

Once a problem or concern is identified and an 'action plan' is formulated, the plan is then implemented. This is followed by the data collection, analysis, and evaluation of the 'action plan.' If the 'action plan' is unsuccessful, it is revised and another 'action plan' may be developed and implemented. All the stages of each action research cycle require the participants to monitor, reflect, and evaluate. The cycles are repeated to move to higher levels of thinking in a collaborative and cooperative environment.

COLLABORATIVE ACTION RESEARCH

As I have discussed earlier on, I intended to locate my study in action research. Action research has the potential to extend and enhance teachers' knowledge base and can additionally result in personal growth through collaboration. Collaboration is one of the key tenets of action research. The types and degrees of collaboration that exist in action research may differ. These are derived from the Lewin model as well as based on the works of Jurgen Habermas. Action research scholars like Carr and Kemmis (1986) have described three modes of action research: a) technical, b) practical, c) emancipatory. These modes represent different philosophical positions about the nature of educational research and knowledge, the main difference being in how power is distributed (Grundy, 1982). In the technical mode, the researcher controls the research with pre-existing ideas about whether the educational practices will be effective. In the practical mode, power is shared by individual group members and they try to improve their practice by self-reflection. The emancipatory approach aims to empower the whole group by developing a critical social awareness. In this approach problems are identified and attempts are made to remove organizational or institutional pressures for effective research. Like the other two modes, the improvement of practice is still paramount, but individuals are given the power to find solutions to problems. However, according to Carr and Kemmis (1986):

> Action research extends beyond individual engagement in the process … Action research therefore precipitates collaborative involvement in the research process, in which the research is extended towards including all those involved, or affected by, the action. Ultimately, the aim of action research is to involve all these participants in communication aimed at mutual understanding and consensus, in just and democratic decision-making, and common action towards achieving fulfillment for all. (p. 199)

Carr and Kemmis's conception of collaboration extends beyond individuals in the team working merely cooperatively.

In my project, I as an external to schools, was to work with the internal school teams comprising of teachers, heads of school, and students. I foresaw possibilities for differences. Although I was to work with the teachers most of the time, I could not possibly ignore interacting with the heads and the students. How could the science teachers, head teachers, and I collaborate on realizing the differences? In the mid 90s, collaborative action research projects at the Institute for Educational Development were pioneered by a faculty team (Kanu, 1997). Since then many other action research projects between the schools and the institutions' faculty have taken place. My experiences of a number of these projects had brought to my attention possible problematic areas internal to these projects. 'Externals'(the institute members) and school members differ in the forms of knowledge, levels of thinking, and expertise which they offer and which creates difficulties and tensions in defining roles and responsibilities. This helped me to realize that the major challenge for collaboration would be on how best to cope with the inherent issues of power relationships in a tactful manner. Furthermore, studying Kanu's (1997) project findings exposed me to yet other possible dilemmas I could encounter in my study and some ways to address them.

Kanu and her team of facilitators at the Institute for Educational Development were engaged in a collaborative action research project with their in-service student teachers from several developing countries and, hence, from diverse backgrounds. The team chose the emancipatory action research approach for two-way possibilities to work collaboratively and for reflection. This was to enhance an understanding about 'selves' and the issues internal to the project. The team faced the practical dilemma of how best to collaborate with teachers given their differences, especially in expertise. The most agreeable approach to the faculty was to interpret collaboration as each member of the faculty or each student teacher contributing to the task what s/he was best able to offer (Kanu, 1997). To facilitate teacher participation and to respect their viewpoints, the team provided the teachers with as much ownership of the course as possible. Although the faculty team had pre-specified goals for course design, teachers were allowed and encouraged to take an active role in formulating and highlighting specific problems,

concerns, and issues they wanted to see in the course. The team members then negotiated the teachers' goals with the course goals to create a new course design. This was to help teachers re-examine their conceptions and develop a positive attitude and stance towards classroom practice. This experience of the team with the in-service teachers demonstrates an important learning which Sumara and Luce-Kapler (1993) have expressed as: "It is during moments of disagreement, of negotiation, of laboring over that which is difficult that we gain insights into ourselves, each other, and whatever enterprise binds us together" (p. 394).

Even though the course design was negotiated, Kanu's team experienced tensions once the design was put into practice. The teachers were genuinely troubled when they were required to question or critique assigned academic readings or the ideas and observations of their project team members. Furthermore, the teachers felt very insecure when the facilitators introduced 'innovative' instructional strategies and ideas based on the constructivist philosophy of learning. Along with the challenges Kanu has also shared a number of valuable insights giving reasons or suggesting ways to resolve some tensions in action research. The main reason being that teachers' culture was at variance with the Western culture which predominantly influenced the design of the course. However, one aspect that I suspect Kanu has overlooked is the extent to which the participating teachers were prepared for this new approach. It is likely that the problem was more inherent in the participating teachers' authority dominated culture. Sudden emancipatory expectations by the facilitators from the students who were still predominantly at the technical level were overwhelming. Hence, the solutions had to be better sought from a third space (intermediate or transitional) in collaboration with sensitivity to the teachers' context. Haggarty and Postlethwaite (1995) argue that:

> 'Emancipatory' action research, in which "the practitioner group takes joint responsibility for the development of practice" (Carr & Kemmis, 1991), is in some ways equally problematic for outside consultants. Carr & Kemmis (1991) argue that "the role of facilitators in a generally collaborative group is one which can, in principle, be taken by any member of the group; an outsider taking such a role persistently would actually undermine the group's collaborative responsibility for the process", with "continued dominance ... destructive of ... the responsibility of the group for its own self-reflection." (p. 171)

The above observations imply that any lack of clear understanding of the notion of collaboration in action research by outsiders can become problematic. It requires a conceptual change about the meaning of collaboration in action research and questioning the modernist notion of objective knowledge. An alternative is to move away from the notion of objective reality itself. Inherent in this are complexities of education that Davis & Sumara have discussed.

Davis & Sumara (1997) see teaching and educational research as complex phenomena and oppose simplistic interpretations/reductions about them. They understand these as complex endeavors and not mere commonsense discourses. For them action research is an 'instance of complexifying' the relationship among the researcher and the research situation so as to blur the boundaries. For this they favor collaboration, but with the following emphasis:

> ... we call into question the possibility of some form of "researcher" identity that pre figures involvement in sites of collaborative action research and argue, instead, that the research activities themselves function to generate individual and collective identities: Action research understood in this way, is not merely a set of procedures that enable the interpretation of culture; action research in an instance of "culture making" in which the various actors are wholly complicit. (p. 301)

'Culture-making' is a powerful concept of collaborative action that Davis & Sumara have in common with Bruner (1985b). Complicity is taken in the sense to become cognizant that every actor has a responsibility to consider his/her intentions and the consequences of his/her actions in tandem with these intentions. Thus:

> ... researchers, in particular, cannot think of themselves as "operating in" educational settings, mining the desired data, and then severing all ties. Complicity compels us to be attentive to a different sort of investment. As demonstrated in the announced research, it requires willingness and an effort to formulate one's place in the community (and not letting such participation go unacknowledged or unformulated) and, reciprocally, to allow that community to become part of the research. (Davis and Sumara, 1997, p. 309)

Davis & Sumara have made the readers search for the question: "What is the meaning of action research as a living practice?" It certainly is not acts of exploitation of data by the researcher. This to me resonates with Jardine's intention as well. Jardine in his essay, "Their Bodies Swelling with Messy Secrets" (Jardine, 1997, p.161), narrates the story of Ellen a nurse, caring for stroke patients. Ellen decides to research her

practice to become better informed about her actions. However, she gets caught in a dilemma of 'data collection' and 'lived experience.' Thus, she raises an important question for herself as well as for her readers: "What is meant by data and lived experience in qualitative research?" Both studies are really asking the readers to rethink what is meant by action research as a living practice.

In my study, it has been equally important for me to question the traditional boundaries of action research. I believed this would free me from the simplistic criticism that I have no right to impose my own value judgments on other communities. As Davis and Sumara (1997) argue, I cannot escape from imposing my value judgments; rather, I must negotiate those judgments within the lived experiences of the others.

Action research, since its beginning, has been committed to change, no matter in what form. As my text speaks I have preferred to anticipate my action research project as a learning opportunity for all involved ('self', teachers, and 'others') and that we all emerge from the process with a deeper understanding and, hence, changed and transformed. This implies learning to do something new. As a result, I envisioned a need to critically analyze the project intentions, especially those committed to empowerment and emancipation. Action research projects, with in built critical intentions and committed to emancipation, also see change as progressive, but not linear. In action research projects, then, a rationally empowered individual is an agent of progressive change. This is also reflected in the language used in such projects: "to become reflective practitioners and change agents" (Titchen & Binnie, 1993); participation, direction, constraints and consciousness raising (Tripp, 1990). Gore (1993) has even attempted to provide a meaning of empowerment in the context of emancipatory action research in a modernistic perspective:

> ... "empowerment" implies (1) a notion of power-as property (to empower is to give or confer), (2) an agent of empowerment (someone or something to do the empowerment), and (3) a vision or desired end state (a state of empowerment). (p. 121)

Unless these meanings are critically considered, there is a danger of using them as regimes of truth. For this reason Gore (1993) further comments:

> These dangers can be seen in number of ways: in the closure that comes from the, "This is so, is it not?" tone which silences other viewpoint; in the limits such assertions place on reflexivity; in what becomes a "strategy of mystification" to which only a select few are given recourse; in the potentially limited impact of the argument, and of discourse in general. (p. 121)

The dangers Gore mentions seemed inherent in Kanu's (1997) team's action research project as well. For example, the tension about the critical thinking between the teachers and the facilitators may as well have been an act of downplaying. Recognizing the possibilities for dangers in the modernistic perspective I wondered how else to understand the change or transformation. The best way I saw was to continuously search for possible free spaces and to squeeze in. This is in accordance with Davis & Sumara's (1997) notion of "enlarging the space of the possible," and developing a new concept of change:

> Much of current research, scientific and otherwise, might be interpreted in terms of pursuing the modernist ideal of progress... which, in effect, represents an effort to manage complexity by reducing it to simplexity, to train it to one's purpose, to use it in the project of better controlling one's situation. "Enlarging the space of the possible" is, in many ways, the antithesis of the ideal, arising from insistence that we are collectively moving towards increased complexity and hence, that we are forever falling short of our desire to render the world manageable. (p. 303)

Davis and Sumara represent the difference between the desire of progress and the recognition of the ever increasing complexity as follows: "simplexity, like modernism, points its desire towards the future, complicity is more focused on the contingencies of the immediate situation, acknowledging that future is dependent on the present, but is not determined by it" (p. 303).

Through their creative notion of "enlarging the space of the possible," Davis and Sumara have conflated the projects of education and research, "both of which involve efforts to deliberately, but thoughtfully, affect the way things are: to enlarge the space of the possible" (p. 310). This is to say, "Educational research is not merely research that occurs in educational settings, nor merely that it is focused on educational issues. Rather, it must be regarded as research that educates, that makes culture" (p. 309).

Davis and Sumara have helped me to come out of the bubble of the modernistic paradigm of change as an 'object' out there, external to my actions, to be attained. I was to follow new footsteps to continue my journey of change as a lived practice in search of my key research question.

THE RESEARCH QUESTION

The major question of this study was: ***An exploration of science teachers' pedagogical content knowledge in Pakistan?*** My lived experiences as a teacher and teacher educator enhanced my interest in understanding and bringing about a change from the 'transmission' mode to the 'transformation' mode in my own teaching. My belief and attitude about reflective dialogue as a powerful tool for professional growth of a teacher was further strengthened. I concur with Nelson (1993) when he says, "reflection is an essential attribute of professionalism because it contributes to critical pedagogy" (p. 154). I was inspired and motivated to continue to gain a deeper and contextual understanding of the notion of teacher development by engaging personally in this research study as well as to explore the issue of the 'pedagogy' of content knowledge of teachers in Pakistan. My intention for this project was to enhance science teachers' pedagogical content knowledge for promoting science and to enhance teachers' confidence and competence. I intended to examine closely the changes in science teachers' practice through teachers' stories and reflective dialogues for different settings: planning, preparing, organizing, and implementing activities and strategies in the teaching of science. Consequently, I wanted to explore teachers' conceptual changes in their pedagogical content knowledge in science in the Pakistan context. More importantly, I wanted to learn from this study to help other teachers and institutes like the Institute for Educational Development for teacher professional development. I had realized that I had witnessed significant changes in the practice of teachers in my five years of work with teachers at the Institute for Educational Development, but I had never examined these changes closely as a research activity.

In the last decade research on teacher education has gained importance and momentum. It is my assumption that this study will help me to understand the change in me as a teacher educator as well as the possibilities for change in the professional development and growth of teachers in Pakistan and elsewhere in the world. In order to understand how participants understand the pedagogical content knowledge of science and their involvement in action research in Pakistan the following questions were considered helpful:

1. What are teachers' perceptions of pedagogical content knowledge of science at the beginning and closing of this research project?
   - How do teachers understand how students learn science?
   - What do teachers know about curriculum materials?
   - How do teachers make decisions about the curriculum?
   - How do teachers make subject knowledge comprehensible to students?
2. How does the process of reflection through dialogues and stories change participants' thinking and belief about the teaching and learning of science?
3. What problems and constraints do teachers face to engage in action research?
4. What are some of the dilemmas and opportunities in mentoring teachers in action research?

DESIGN OF THE STUDY

Smith and Neale (1989), conducted a summer program for 10 primary science teachers to understand, facilitate, and document conceptual change in teachers content knowledge and the teaching and learning primary science. They reported that as the participating teachers changed their understanding of the subject content and how to teach it using effective strategies, they also taught differently. From Shulman's (1987) perspective of 'pedagogical content knowledge' teachers' ability to teach was enhanced. The authors further go on to write:

> Teachers' knowledge of the content, their translation of that content into appropriate and flexible usage in lessons, their knowledge of children's likely preconceptions to be encountered in lessons and the effective teaching strategies for addressing them, and especially their beliefs about the nature of science teaching, all proved to be critical components in the changes they were able to make in their teaching. (Smith and Neale, 1989, p. 17)

The author's work has informed me about the role of appropriate activities in search of answers to my exploratory key question. In order for my participating teachers to apply their new understandings in the classroom, it was necessary to develop and examine materials they used in the classroom. The researcher worked alongside to advise, guide, choose, design, and prepare tasks and strategies for the science classroom.

Qualitative methods were used to combine observations of teachers engaged in science activities (planning, preparing, and teaching, reflecting … and repeating the cycle) with conferences and conversations about instances and events. In addition, narratives/stories about teachers' teaching and learning designed to explore meanings that these experiences hold for them were also used.

To further pursue reflective practice to enable me to look for possibilities for developing critical mindedness, in consultation with the teachers, I scheduled: conferences, conversations and discussions on a one-to-one interaction basis with each teacher; narratives, discussions, and tutorial sessions (as needed) as a group with all three teachers at appropriate times. With the teachers' permission, conversations were audio recorded and a select number of lessons were video recorded. During the group sessions transcripts of the audio taped sessions were used to explore ways to portray the ways teachers think, make meaning, and reflect upon their development. Audio recordings were transcribed and shared on regular basis with the participants for comments, accuracy, and validation.

METHODOLOGY

Conversations

I employed conversations as a research methodology because of the possible openness of conversations. Openness is used in the sense that the answer is not determined in advance; that is to say, the research will remain open to new questions that arise during the conversation. As a result, this enables us to see that there are areas that remain to be investigated and it allows the conversation to continue further. "The art of questioning is the art of questioning even further, that is, the art of thinking. It is called dialectic because it is the art of conducting a real conversation" (Gadamer, 1989, p. 367). The openness of the question is also realized where the participants are genuinely interested and willing to hear the other's voice and to develop an understanding about something that is of mutual interest to them, but which is presently indeterminate (Gadamer, 1989). Engaging in conversations was, thus, to help the teachers and the researcher ponder over the purposes as well as the content and pedagogy of science, voice the challenges, come to an understanding, and struggle to find viable alternatives

for teacher development. Moreover, the conversations also helped the teachers to become aware of the possibilities and challenges of implementing new ideas.

As a researcher, I was to function as a facilitator of the conversation. Following Gadamer's (1989) guidelines, I intended to remain open to possibilities through personal journaling and to encourage participants to keep journals to enter their questions or concerns. Reflections on these conversations served to disclose themes (van Manen, 1990) as well as contradictions (Carson, 1986) which were taken back to the participants as subject matter for further clarifications and validation.

Conversations required some explicit topics to begin with and needed to start somewhere. Some specific conversational starters, in my case, to facilitate the conversation and to explore participants' perspectives about some of the guiding questions on pages 35-36 of this chapter were:

- If I was to visit your science lesson what would I see a) you doing b) your students doing?
- What would I see you doing outside class in your school as a) a science teacher b) a teacher?
- It is generally felt that there is a relationship between what teachers know and how they teach. What do you think?
- How do you think children learn?
- As teachers or teacher educators, what is our purpose of teaching science to our children? What concerns us to be able to teach science effectively?
- How do you think you will benefit from this project? What appeals to you about this project?

Though these conversational starters are framed as questions, they served only to orient our conversations and not to control and direct the conversation like interview questions.

Data Collection

Data for the study were generated through interactive conversations/dialogues, the teachers' stories, and my personal observations. The identified methods for data collection were:

- Conferences with teachers: individual pre- and post- lesson conferences for every lesson observed (as participant observer) or co-taught; and group conferences,
- Classroom observations of participating teachers' science lessons,
- Examination of documentary evidence: personal document (personal reflective journal), teachers' plans, field notes, pupils' records/artifacts, and reflective journals (with teachers' permission), and
- Informal conversations: telephone communication.

On the average, we had one group session per month with a total of about nine group sessions for the period September 2000 to April 2001. However, the effective number of months (reasons for this will be discussed in chapter 5 of the thesis) for field work at the school sites turned out to be about three and a half months for PT and Saira, and about two months for Nina. This meant sharing about fourteen lessons (one lesson an hour long per week) each of PT and Saira and seven lessons of Nina. All lessons and group sessions except for group session four (technical problem) were audio recorded. Initially three lessons one for each member were also video recorded for reasons discussed in chapter four. Almost all audio and video tapes were listened to and transcribed without much delay, preferably on the same day or within the same week to complement the field notes and raising questions and issues. A record sheet was generated. No doubt this was a time consuming process but it was rewarding.

Journal writing was for documenting individual thoughts, feelings, and reflections. Though my partners were used to it and had experienced journal writing during Subject Specialist Teachers' Program they still found it challenging. Their reasons being time constraint and struggle to go beyond mere description and question raising stage. However, they made an effort to keep up with entries of the shared lessons and group sessions. This provided useful information about their concerns, perceptions, and attitudes towards teaching and learning. During the course of the project I introduced another tool titled 'Grid.' At a later stage under appropriate section its conception and description will be discussed. One of the group participants had a good description for the 'Grid:'

> in it we have written records, although we have written down ... happenings in ... reflective journal and notes ... we wrote it in our Grids in more concise manner, choosing things selectively ... it gives the whole picture of what we did and learnt. (Dialogue Group Session, Nina March 2, 2001)

Data Analysis

The data analysis was carried out continuously as the research proceeded and evolved and questions/themes emerging were addressed accordingly. The results that were to emerge were to be interpreted in collaboration with the participating teachers. The use of multiple methods of data collection and the subsequent triangulation of interpretations (Eisner, 1991; Miles & Huberman, 1984) allowed me to check perceptions of self and others from data obtained from multiple sources. This was done by comparing and cross checking the data from different sources e.g. classroom observations, discussions, journal entries (personal and participants) and then going back to participants for further clarification and validation. The intent was to provide a more complete and comprehensive understanding leading to valid conclusions.

Participant Observation

I did foresee 'engagement of self' to be a central and problematic feature of my research. How far would what I saw in classrooms or significant/relevant surroundings be conditioned by: first, my theoretical perspective and second, my own involvement in the activity that I would observe? My worry was about subjectivity and my ability as an observer to become sufficiently distant from what I observed and the issues it would raise. Eisenhart (1988) states "the researcher must be involved in the activity as an insider and able to reflect on it as an outsider" (p. 103). As a researcher, I recognized this as a challenge with which I had to deal. I envisaged my probing rather than 'telling' would have the effect of allowing the teacher(s) to stand back to reflect upon her/(their) own work and delve more deeply into his/her/(their) own motivations and beliefs than the teacher(s) is/are likely to do alone.

I also realized that my presence could be a perturbation on the classroom. This could create dilemmas in terms of the teacher and the students' expectations of me. Was I to be just an observer, as unobtrusive as possible, staying in one place, not initiating any

conversations either with the teacher or with the students in the class, or play a role of participant-observer? The former role, I believe, had a serious disadvantage in terms of what I could see and hear, whereas, the latter (once my presence became familiar to the students and permission would be granted by the teacher) would be a compromise to enable me to move around the classroom, audiotape interactions, and address the students more directly. This was to rationalize the situation of myself as a participant-observer. Though this had a high potential for informing the study since it situates the researcher in the setting, it is problematic. This called for issues of trust, confidentiality, and intrusion to be dealt with great care and sensitivity since the researcher as a participant-observer was actually to encroach on the teacher and the students' territory. In all cases, the teacher(s) as well as the students had to be willing to invite the researcher (through negotiation if required) into their microcosm or turf. The other problem arising would be about note taking. As an observer field notes could go on simultaneously; however, as a participant-observer the notes had to be completed immediately after observations or discreetly, when possible.

RESEARCH ETHICS

Written consent was obtained from all participating teachers. They were informed that their participation was voluntary and that they could opt to participate or not at any time they chose by informing the researcher. Written consent was obtained from all the teachers and students to video and to collect samples of their written work where appropriate. An effort was made to recognize and respect the teacher(s) and the students comfort level with regards to dialogues/conversations and video recording. Sample written work of students (with permission from students/teachers/parents/ guardians as appropriate) was photocopied from ungraded originals and names were removed.

Ethical considerations in the interpretation of the data included consulting and dialoguing or conversing with the teacher(s) about the events and their interpretations. The descriptive accounts of the engagements were to be shared with the teacher(s) to request them to assess the validity and accuracy of the accounts and to comment on the interpretations. Group discussions and individual dialogues/conversations were to be set as short as the teacher(s) were comfortable since it would be difficult to set longer time

periods out of school time due to the teacher(s)' commitments. To ensure anonymity, the names of teachers and students were changed in all the accounts and portrayals. The teachers were to be assured and reassured that the study is not to evaluate, but to foster constructive social change.

INTERPRETATION AND REPRESENTATION

Interpretation and representation bring to light the multivoicedness of meaning and the problem of criteria. The issues cautioned me to reflect and question my interpretation and my writing or articulation of the study: Who is doing the talking? Who am I talking about? How well do I know the teachers and their experiences? How best do I represent their voices, experiences, reflections, actions, and development? What criteria do I select/use to represent all this? These questions were paramount to my study and were to be explored as issues. A way to address these questions was through the use of collective voices. Once I read the transcripts, themes/ questions emerged. These were: shared with the group for their comments and validation; checked against data from other sources (field notes, journal entries, and children's artifacts); and paralleled with findings of different researchers for triangulation (Miles and Huberman, 1984, p. 235).

In conclusion I posed another problem. My conceptualization/thinking of my research interest seemed to have threaded through the concept of 'mindful awareness.' That is to say how it was inquired into, articulated, interpreted, and represented was not carved in marble. At this point in time I saw it as more than self-reflexivity and empathy. It required raising one's consciousness to the basic things that we normally take for granted including our biological nature, our relational nature, our desires and intentions and to recognize that these are essential to knowing and learning.

SIGNIFICANCE OF THE STUDY

The significance of the study lies in two areas: a) the question it intended to explore and understand; and b) the qualitative and interpretive methodology used. I believe both will contribute significantly to the body of teacher education research in Pakistan in general, and enhancement of pedagogical content knowledge, in particular, through teachers' stories and reflecting upon them. I expect, in addition, that this collaborative

action research study to explore successes and challenges to enhance teachers' pedagogical content knowledge will be a springboard to many more studies focusing on specific issues highlighted by this study. In this study, I saw participating teachers representing themselves as persons, science teachers, and researchers. The study exemplifies a different kind of research relationship that is built on trust and a more equitable power relationship which is different from the 'research on teachers' predominantly used in Pakistan. This study helped the researcher to develop a deeper and broader sensitivity and awareness of science teacher development. This study also paved the way to identify science teachers' perceptions of the successes and challenges they face within the larger framework of other contextual factors. Thus I believe the study to be beneficial to a) the participating teachers b) science teachers and teachers in general c) teacher educators d) researchers worldwide and e) self. The implied 'change strategies' to empower a small group of teachers will hopefully be the start of a ripple effect to build a critical mass of effective teachers in developing future leaders to initiate further growth and change in their colleagues.

SETTING THE CONTEXT AND BEGINNING THE VOYAGE

I have come to believe that science teachers in a supportive and collaborative environment can be inspired and motivated to strive for their professional development. More importantly, I have witnessed that teachers are central to improve the quality of learning in science classrooms. My underpinning assumption, then, is that teachers' participation as partners is central to the research process. This notion is in line with Kosmidou and Usher's (1991) notion that teachers become an integral part of inquiry and assume a position of equal participation and authentic co-researchers. Furthermore, by engaging in critical-self reflection the university researchers/facilitators are more likely to blur the boundaries between academics and the teachers. Without this self-reflection, hegemony between academics and teachers may result and create tensions. As a result, the action research may be reduced to a technical mode. Somekh (1994) comments "collaboration is always fraught with difficulties and complete equality is probably impossible to achieve in any partnership" (p. 365). With these guidelines, as a facilitator

of the action research group, I attempted to foster as equal and genuine as possible a partnership with the participating teachers.

Throughout my doctoral residency period (September 1999 – August 2000) at the University of Alberta, I actively planned and prepared for my fieldwork, especially for the initial action research meetings. Indeed "the art and science of 'planning' is somewhat enigmatic to the action research process" (Pedretti 1996, p. 310). I consolidated my efforts and time researching, reading relevant literature, writing, and communicating electronically through the Institute for Educational Development with Subject Specialist Teachers who were accessible on line. All the teachers with whom I communicated were interested and willing to be participants/partners in the research. Considering that the teachers were female and would have to make time outside school hours for this study, I selected them from schools with easy access to the Institute for Educational Development. This made traveling safe, comfortable, and convenient for them.

I was fortunate to visit Karachi in April 2000. I took this opportunity to provide the potential participating teachers and their respective heads with my written project overview and consent form (see appendices A and B). I also visited each school personally and met first with the head and then the invited teacher(s) to once again orally explain the purpose and expectations of my project. The heads appreciated this and welcomed my initiative with encouraging yet questioning words:

> These teachers need such experiences. They are used to … (lifts up a pile of folders of preprepared lesson plans and shaking them up and down) take these … do 1, 2, 3… stepwise. They have not learnt to take decisions or solve problems … but … they do as they are told … it is recipe approach they follow. It is wonderful you decided to come personally to school to deliver the invitation letter and talk to school head and teachers … this is the first step to collaboration and shows personal interest and commitment. I like the idea of invitation, it is not commitment or saying go do this … (Head of a school, 13/4/2000)
>
> "What will be the incentive for these teachers? Will they be part of your research? Will they appear in your thesis?" (another school head, 13/4/2000)
>
> "Our school will definitely benefit" was what the third head said. (13/4/2000)

I considered the heads' queries and words worth thinking about in relation to the question 'in what ways participating teachers would benefit or gain from the project?'

This helped me to put more thought into my project undertakings. The heads had shown an interest and, undoubtedly, were part of the process; their collaboration and input was vital for the project to go forward.

I had my ninety-minute orientation/invitation group meeting with 4 out of 5 of the invited Subject Specialist Teachers on April 21, 2000 at the Institute for Educational Development. I was impressed by their punctuality, willingness to stay on longer than an hour which I had originally planned, and by their openness. They had many questions to ask and they demonstrated this:

> Of course, we are asking these questions so we should be aware of all these things before participating in this research. So we can know… are we able to give time or not…what will be happening during that time period. We just want to be clear on this. (Group Session April 21, 2000)

Three of these Subject Specialist Teachers already by the end of this open session got convinced and willingly accepted to become group members and signed the individual consent forms, though they highlighted certain concerns:

> time is the main problem …teaching … then other responsibilities within the department and headship… it takes a lot of time and commitment. So you (meaning researcher) see it takes a lot of time and late hours. Sometimes it takes more than eight hours and sometimes we don't even know our schedule… we don't know what will happen next day. Once we make a commitment we wouldn't want to leave. (Group Session April 21, 2000)

One of the other invitees had this to share:

> I have only one problem that I do not come here (meaning to school) odd hours … if you can manage the research during school time and Saturdays … I have off … so I am very pleased to do this research otherwise if it is odd hours … (shying away) … you know life is so difficult after marriage … (laughs in a sense of humour, group laughs with her). During school time I do not have any problem. We have four Saturdays … if we meet in morning here or anywhere else I have no problem … but in the morning. (Group Session April 21, 2000)

They also suggested possible solutions to the concerns especially for time commitment. In spite of all the planning preparation and achievement up to this point in time, I realized the evolving nature of the process led by participating teachers. One of my three initial members died suddenly in late May 2000 even before fully embarking on the journey. My journal entry before leaving for Karachi reveals my mixed feelings:

> I am almost ready to leave for Karachi to begin my fieldwork in earnest early September 2000. I am excited, yet I am uncertain whether or not I will get my third participant. Two years ago as a facilitator of Subject Specialist Teachers I had established trust in them. Since then these Subject Specialist Teachers have been in their respective schools/systems for fair amount of time. They have moved to different levels or positions in the hierarchy of respective schools/systems. There are those who are now married and have moved to another place or have own children; and others have become head teachers or heads of departments or subject co-coordinators and couple have even joined MEd program at the Institute for Educational Development. Who would be my third participant? What if one of the two I already have decides to drop? (Charan Journal entry, August 29, 2000)

In September, before the actual fieldwork period, the participants were invited to the first project group meeting at the Institute for Educational Development to revisit the purpose and nature of my research, to make a tentative schedule, and to identify venues for classroom observations, dialogues, and group sessions. During the course of my fieldwork period (about six to eight months - September 2000 to April 2001 - with about two months for the winter break and exam period) my partners were required to: open their science classes for observations; make time (outside normal school hours) for conferences/dialogues and group sessions; keep a personal reflective journal; plan/prepare/reflect and to engage in any emerging, related issues that unfolded. They were to do this in addition to their normal school routines.

My visit to the schools as well as my encounters and discussions with the school heads and the Subject Specialist Teachers raised my awareness of my multiple roles. This was further clarified by my readings of Hardy and Kirkwood (1994) and Oja and Smulyan (1989). I realized that, besides being a researcher, I would be a facilitator, a support person, a resource person, a catalyst, an expert, and a critic.

RESEARCHER AND FACILITATOR ROLES

To this dual role as facilitator and researcher Kosmidou and Usher (1991) have described the assumptions, limitations and even at times the incompatibility between the two roles. I needed to be consciously aware of how to interpret my role. How would the group respond to me? To what extent would I provide structure and leadership to the group? How could I improve my practice? How could I help participating teachers to improve their practice?

I situated myself not only as a researcher, but simultaneously as a facilitator or, at times, playing either/or roles. Much of recent literature on action research informs that those who research and facilitate the process of action research have generated the debate about philosophical and methodological aspects of action research. That is to say, that the university researchers/facilitators of action research thus engage themselves in second-order inquiry; "constantly deliberating about their own practice and its relationship to the nature of the activity they are trying to facilitate" (Elliot, 1985, p. 259). Consequently, university researcher/facilitators' engagement in critical self-reflection about their own role in action research process has a greater likelihood to narrow the theory and practice gap and help practitioners 'get to where they want to get' (Kosmidou and Usher, 1991). My role as researcher/facilitator of an action research group helped me to gain insight about the nature of action research, to develop and enhance my facilitation skills, and to foster collaboration that supported the project participants in identifying and pursuing their goals, meeting their expectations and aspirations. As a facilitator, I envisioned mentoring as my major role.

Roles as a Mentor

I do accept that change is a slow process and it can have both up and down moments. I also believe that change can only materialize when individuals first themselves recognize the need for change and then are willing to change. I do subscribe to Louden's (1991) view:

> Teachers teach in the way they do not just because of the skills they have or have not learnt. The way they teach are also grounded in their backgrounds, their biographies, in the kinds of teachers they have become. Their careers ... are also important for teacher's commitment, enthusiasm and morale. So too are relationships with their colleagues either as supportive communities who work together in pursuit of common goals and continuous improvement, or as individuals working in isolation, with the insecurities that sometimes brings. (p. vi)

The changing roles of teachers I envisioned as: creating independent learners, developing activities that would engage learners, and questioning so that students are made to think ... in accordance with Brissenden (1988) who discusses the new role of a teacher as planner and organizer of experiences, an acute observer and a good listener.

Cockcroft (1982, paragraph 250) also emphasizes the need for practical work and investigations thus seeing the teacher as a stimulator, encourager, and guide.

As a mentor I had to play the supportive role in helping the participants or professionals. This is described in different ways by different scholars; co-thinker (Feiman- Nemser, 1991), critical friend (Watson, 1994), supporting fellow professional, listening friend, and supportive critic (Nolder, Smith and Melrose, 1994). As for my relationship with the group members, I questioned the sort of an atmosphere that would allow and support personal growth and change. Watson's (1994) guidelines appealed to me and seemed most appropriate given the diverse nature of my group members. She lists listening and encouraging, responding to others concerns and needs and building trust ... "holding and letting go" (p. 4). As she comments:

> I try to provide a combination of support, limits and a psychological home base. I do not try to cushion students from the realities of the job or from the challenge of personal change. I cannot imagine how one could do this. In most schools the problems and stresses are only too apparent. The challenge is to turn these factors into issues about which one can formulate a view and hence build one's practice. (p. 5).

Kay (1990) has similar thinking that a mentee should receive encouragement and unconditional acceptance "as a person, regardless of the success or failure in the task" (p. 31). Emotional safety is necessary for experimentation and chance of failure. This was an essential consideration for my project as was the need for empathy, what Philips (cited in Gray and Gray 1985) has described as taking a personal interest in the mentee's career and personal well-being.

In my project, the mentoring process for the period October 2000 to May 2001 involved co-planning or collaborative planning, co-teaching or team teaching or simply being a participant-observer, demonstrations by the mentor and conferencing or dialoguing. The extent varied as per need of the individual member, the nature of the topic and the situation. The overall purpose was to aid the members to adopt a more reflective focus rather than 'telling' and instructing, though at times that was also necessary. In an attempt to question 'what is to be my overall responsibility or role as a mentor?,' I followed Smyth's (1987) view of 'pedagogy' that a pedagogical action should aim at 'empowering' learners (teachers). This to me was crucial to my project with the intent that it in turn will empower their students.

With this in mind the project group members had the freedom to innovate, decide, and act according to their needs, experience, understanding, and the situation in which they conducted their practice. However, suggestions were made or ideas were shared at appropriate moments to offer alternatives for consideration. Embedded in this I saw my role as a facilitator and stimulator in this process to provide moral and technical support, to create an environment for the teachers to be able to inquire into their practice and to support their efforts in this direction. Thus I was also a promoter and attempted not to manipulate or distort the content or the process to fit my own purpose (Elliot, 1991). A question subsequent to this was as a mentor 'what kind of relationship do I need to create with the members?' I strongly felt I needed to create a positive relationship with the members with whom I was working and certainly not to exploit them. I wanted to strive to enhance their competence and confidence and to extend their independent thinking. In doing so, I had to keep in mind that my group members were people with different perceptions, view points, and rich in knowledge that has been accumulated from practical experience though some of it was tacit.

RESEARCH PARTICIPANTS: THEIR BACKGROUND AND EXPECTATIONS

My participants, three committed and willing in-service science teachers, were from a cohort of fifteen teachers (14 female and 1 male) from class of 1998 of the one year Advance Diploma in Subject Specialization from the Institute for Educational Development. I had coordinated and facilitated this first of its kind program that focused on enhancing these teachers' science content knowledge predominantly through a strong emphasis on a contextual field based approach. I had witnessed visible growth in the teachers and I attributed it to the influence of reflective dialogues. However, I realized I had not worked closely enough with these teachers to gain insights into the realities of the challenges and constraints they faced. This urged me to embark on this research endeavor and work closely with a small number of these teachers for an in-depth study into the possibilities and constraints of teacher development contextually.

The first action research group session on September 15, 2000 was to: welcome the new member on board; revisit the overview and consent letter especially for the benefit of the new member and for further clarifications; explore members perspectives on the

teaching/learning of science and any pertinent concerns; negotiate and schedule classroom visits and the group session; establish the group's common purpose. This was also a time for me to get better acquainted with the group and let them know that, though I was a researcher, I still was, to a great extent, a facilitator and a teacher as well. For this we shared our personal stories and talked around seven focus questions. Five of these focus questions (see p. 38 above) were sent to the participants before the session date to think about and, if comfortable, to respond to in writing. I was also able to share the five questions with the Institute for Educational Development (IED) director for his comments. I was pleased to receive written responses from all three participants on the questions and their willingness to share their efforts with the group. Some questions posed problems for them in terms of familiarity or articulation (For a summary of these responses and my comments see Appendix 1). This was an encouraging start. The participants' stories were indeed fascinating and enriching. Hesitatingly, knowing that participants have busy schedules, I suggested 'why not write your stories?' The spontaneous response to my surprise was positive and fair, 'Yes, yes, certainly … from this we will indeed learn … but give us time.' My assumption that participants have no time obviously was not quite correct. On the contrary participants liked the idea for a purpose and, hence, were willing to pursue it. Therefore, it was only fair to allow participants time and mental space. One of my participants rightly expressed this in her story under the heading 'My Comments About this Story:'

> When Charan asked me to write my teacher development story, I felt it was a tough job for me to go back into the past and recall all incidents. But when I started to write the story I felt I looked at myself from the very beginning. Now I have good memories/treasures with me. Which will always be with me or when I will read it after one year may be I would add some/more things to it. (Saira)

It is worth noting that this participant has used the researcher's short name. Culturally, even the first full name is unacceptable because of the tradition of respect for elders and people with higher qualifications/status; particularly in Pakistan, a very status oriented country. However, my participants had come to accept it through my open dialoguing and sharing that it made me feel more comfortable to relate to them as adults and partners. This was not easy and instantaneous for the partners. They had to break a tradition that took them time and effort. It certainly was a change from Mrs. Pardhan (as

I was called during Subject Specialist Teachers Program) to Charan, as we worked together for the project.

Written stories (handed in two months later as per our agreement), the participating teachers' (Nina, PT and Saira) responses to the focus questions, my journal entries and field notes, and informal conversations formed the basis for presenting table 3.1 and writing the individual participant backgrounds and the interpretations thereafter.

Table 3.1: Participants' General Information

	PT	Saira	Nina
Academic Qualification/s	BSc (1983); MSc (1984) both in biological sciences, from Karachi University, Karachi, Pakistan through English medium	BSc (1984) in biology and chemistry from Sir Syed College, Karachi, Pakistan; through English medium	BSc (1971) in Microbiology, Physiology and Biochemistry from Karachi University Karachi, Pakistan through English medium
Professional Qualification	None	None	None
Professional Development	Visiting Teacher Program (1997); Subject Specialist Teachers Program (1998); Both from the Institute for Educational Development, Karachi, Pakistan	Visiting Teacher Program (1996); Subject Specialist Teachers Program (1998); Both from the Institute for Educational Development, Karachi, Pakistan	Visiting Teacher Program (1997); Subject Specialist Teachers Program (1998); Both from the Institute for Educational Development, Karachi, Pakistan
Reason for taking up teaching as a career	Personal; domestic	Interest/motivation to teach science	Personal; family and school heads interest
Teaching Experience	10 years; full time teaching classes 1-3 (girls age range 6-9)	12 years; full time, mostly teaching class 5 (boys average age 11)	22 years; part-time mostly teaching biology to classes 9 & 10 for National Exams (boys age range 15-16)
Other Responsibilities	Science Coordinator for all science teachers classes 1-3	Science Coordinator for all primary science teachers and deputy head for the primary school	None
Medium of Instruction for own schooling	Mostly English	Mainly Urdu	Mainly English
English Language Use	Comfortable with	Makes herself understood and strives to improve	Comfortable with and well-articulated

Nina as a child taught imaginary students yet she was never keen on becoming a teacher but a doctor. Nina feels, she could not obtain the required entrance mark to make it to a medical school in Karachi because she spent more time on sports/athletics and less on studies. Furthermore being the only daughter, her parents did not allow her to go to any medical college away from home city. Therefore, she ended up pursuing a BSc honors degree with a subject combination of her interest and related to medical sciences. As a student Nina remembers her science teachers being good at giving theoretical explanations and examples from daily life experiences, but never engaging students in practical experiences. She illustrates this by one of her incidences:

> Once I remember my physics teacher was teaching us reflection of light. She showed us a candle reflected in a mirror and gave an oral explanation of the image. This I never understood and that's the reason I never liked physics because most of the terms were not well understood by me.

Nina decided to teach only for a short period of time when her younger son of school age refused to go to school. She taught at her son's school for a while until her son took a liking for school. She wanted to resign but the principal of the school encouraged her to stay on. Thus she entered the teaching profession. She started off her teaching as a grade three (age group about nine) part time teacher. Within a period of four years she was assigned to teach biology to senior classes, mostly matric classes nine and ten. Until recently (for twenty two years) she taught biology to these classes. She remained a part time teacher for family commitment reasons. For this time period Nina describes her teaching as such:

> my teaching was stereotype ... giving explanations, notes i.e. more of rote learning rather than conceptual learning ... For example in class five I gave a lesson on 'Expansion of Substances.' I drew diagrams (of ball and ring experiment) on the blackboard and gave verbal explanation on solids expand on heating (telling iron ball will not pass through the ring when heated) and why railway lines have gaps but I failed to explain these experimentally using relevant materials such that students get hands on experiences and have a long lasting memory of the concepts.

A turning point in Nina's teaching came during the period 1997-1998 when she had the opportunity to attend and successfully complete two professional development

programs at the Institute for Educational Development, Karachi. She had enhanced her pedagogical as well as pedagogical content knowledge:

> The change that I feel in me is in the making of lesson plans, using different strategies, looking for new and innovative activities such that my students benefit from them by understanding and applying the science knowledge gained in their everyday life and future career ... I have become more eager to make science learning interesting and effective for my students. For my lesson plans the activities I chose for the students to perform also enabled me to find out more about my successes and also where I failed to achieve my objectives. Another change that I have felt is that I preplan my syllabus and choose topics for which I could demonstrate or students could experiment where by they (students) learn to perform, observe and conclude.

She next shared one of her many successful and inspirational lessons that reflect her pedagogical content knowledge growth as well:

> I collected materials/resources ... a CD as well, on about ten different types of movements of plants and animals. In a class of 40 students and having only one computer I divided the class into two groups to observe these movements. Students then (in small groups) were given pictures of animals and plants in action and they had to paste these pictures and name the type of movement and organ of movement. The students watched with pin drop silence in class, which was beyond my imagination because I always thought that it is very difficult to perform an activity of any kind with a big class keeping discipline in the class.
> For evaluation I had a big chart with pictures of plants and animals on the blackboard and randomly students were called to write the type of movement and organ of movement.
> I was surprised and inspired to find how well the students understood the concept of movement in plants and locomotion in animals ... I have moved from rote learning to more conceptual learning by providing students more of hands-on experiences. My school administration has always been very cooperative and is always ready to help me by providing me with facilities for conducting classes in this changed manner as they hope that other teachers will also be motivated.

Nina's commitment and dedication to improve her practice and make learning more meaningful for her students has obviously been visible to her administration. During the academic year 2000/2001, there was an immediate need for a biology teacher to teach the Cambridge Classes IX and X (the same age group as the matric but taking overseas exams rather than national local i.e. matric. As such the syllabus differs in content breadth and depth ... also the nature of the exam differs). The principal assigned this to Nina. On September 8, 2000 I extended an invitation to Nina to join the project. She shared this:

> I am still teaching biology, but since the beginning of this year I am given to teach a Cambridge Class instead of matric. It is more content-oriented and very challenging. It is new for me. I teach twice a week class X. I have just started. I am just learning and cannot know like the

> Matric. Matric I can tell you even without having to go and look for syllabus. But Cambridge is new with only six students and I have yet to know the whole.

For Nina, joining the project was very timely. She viewed it as:

> Working with Charan (researcher) who was my facilitator during my SST course will be quite interesting and timely because her critical appraisal will further enhance my development as a science teacher. I think her feedback and how I can improve from it and apply it to my students will be very useful for my science teaching especially for Cambridge classes. I am looking forward to Charan's observations of my lessons and working and learning together.

PT though born in Pakistan has had the opportunity to live abroad in Czechoslovakia during her school years from 1973 to 1977. As a school child, PT had some strong memories:

> When I was a schoolgirl in Prague, my science teacher used to take us into the garden. And we were asked to dig plants and see what the different parts of these plants were. Then we had to clean it from soil (it was small grass) and stick it on our copy. Then label the parts. When studying zoology and trying to find what type of animals lived in it. These are some of the memories which are strongly fixed in my mind. (Journal Entry 19/9/2000)

As for her teaching, PT described it as: "I used to teach General Science and I used to teach through preprepared lesson plans as it is the practice in my school." When expressing the influence of her past experiences on her teaching of science, PT had this to say in her journal entry of 21-9-2000, "I don't remember anything which can influence me to be a science teacher. Regarding my problems which I had it was dealt with during my SST program." With respect to her current position PT further wrote, "But now I don't think or remember any area where I faced any difficulty. The problem, which I am facing, is large classroom strength of students, which nobody can solve. So it's better to compromise with it? After going through SST program I am satisfied with my teaching."

PT describes her being part of the project as: "We can learn from each other by sharing ideas and also I would like to know more about action research and how it can be carried out, so I can learn it and it will help me to improve my own teaching."

Saira describes her boredom and demotivating experiences as a student:

> when I look at my past and think of how I was taught a science lesson I remember the topic 'Characteristics of living things' explained by the teacher from a book (simple lesson) reading and also explained it in Urdu. I felt bored because I couldn't understand what she was saying. But for getting good marks I started rote learning .... At college classes teacher gave lectures that I never understood. When she (teacher) gave demos or did dissection session I always tried to understand but I couldn't. This is why I hated physics because nobody explained to me and our lecturer had

> no extra time for me. They taught me in their traditional style. I would come home and try to explain to myself.

After her graduation, Saira began teaching in the afternoons at a primary school. At that time the head of the school assigned Saira to teach class II, but not science. Saira expressed her feelings as "I became very disheartened because I wanted to teach science. Science has always been my favorite and liked subject and I thought I would enjoy teaching it." After one year there was a vacancy for a science teacher. The Head teacher offered Saira to teach science to classes IV & V and Saira was pleased and motivated:

> I was happy to become a science teacher in 1990. I started coming early to school to observe morning classes of a more experienced science teacher. I carefully observed her teaching style. I would then try to include her style in my teaching. I wanted to do some things differently in my teaching and planning. So I would prepare some activities, which were also appreciated by other teachers. In 1993 I taught science in both shifts.

Since 1989 Saira still teaches primary classes, mostly class V, at the same school. Of late she teaches only the afternoon shift. Saira shared some of her striking experiences and activities that she claims have enhanced her development and her personal as well as professional knowledge:

> I remember my first meeting with Charan (researcher) when she first came to our school in 1990. She wanted to support science teachers. Yes I remember ... I was apprehensive and scared at that time. How well I communicated in English with her ... only she knows better. She talked to me completely in English and I tried hard to give my responses in English. How I communicated ... in right way or wrong I don't know ... but this remarkable event has always stayed in my mind.

This challenging incident stimulated and motivated Saira to take action to improve her English language skills, concurrent with improving her science teaching and learning, through different avenues:

> I joined different courses during my school timings for English proficiency ... I started reading books to support me to use language more appropriately. I would apply this language in my class with my students. Sometimes I would record it and then listen to it. I attended workshops for Science and English language teachers ... with help of facilitators ... in a team of other teachers I prepared some science resource packages in English. These packages also gave me new ways for science classroom teaching. By this time our school had switched the instructional language from Urdu to English ... Subject Specialist Teachers Program, enhanced my content knowledge as well as my pedagogical knowledge. We prepared unit plans and used them in our classes and got feedback on them. I have a very curious nature. I have applied most of the techniques I learnt in my class to make my teaching effective and meaningful. I have continued my journey of 'self' improvement. I have learnt many things ... I have met remarkable personalities like Charan and other senior people who always remember me and support me.

Saira has grown personally and professionally since the early nineties, yet, her struggle is on going:

> Today I do my work more confidently and independently and I go to my class with these ... How can I create their (students) interest in the topic and how they (students) then can relate the topic to their surroundings? How can I help to develop skills in them? Skills like critical thinking, problem solving and be able to answer reasoning questions. All this takes me forward and more forward.
>
> Now days I teach only one shift so I have time to share my learnings and experiences with other teachers. I invite other teachers to observe my classes also. I also conduct workshops for new teachers at school as well as outside of the school. All this makes 'my-self' strong and I learn more. All these make me more confident and knowledgeable and enhance my potential. My struggle is on going, I am always in search of more and better ideas and ways.

Saira envisioned several benefits for becoming a project member:

> I have the same to say as PT. It is new for me to be involved in research and *I wonder what we are going to do*. Secondly I want to improve my *personal growth* and know how I can *reflect myself*. It will affect my teaching ... make it become more effective. I read research has phases ... planning, action, observation and reflection ... *Observing* (third phase) can benefit our students ... 'How can we observe the students and then how can we reflect on teaching' ... comes to my mind. *In a small group we can learn more in a better way* than in large group. I must also learn English. (Emphasis Saira's)

STORIES HAVE MUCH TO OFFER

In the participants' personal professional journey stories, I have found that some parts of their stories strike a chord within me and the stories of the many teachers with whom I have spoken, especially since the early nineties. Some of these being: beginning a teaching career with formal academic qualification only; teaching initially the way we were taught; striving to become expert science teachers either by observing a more experienced colleague or when something or some opportunity triggered them to re-examine what they were doing in their science classrooms and reacting to the stimuli. Nina and Saira's stories, in particular, highlight how they followed upon the reaction to stimuli with reflective and critical observations of their own teaching, sought other ideas about teaching science to their students, decided what worked and what was practical/suitable, and tested it in their own situation. This is in line with the Bereiter and Scardamalia (1993) notion of "progressive problem solving" what people do to become experts in a particular field or domain. These participating teachers had without a doubt set their sights on becoming more effective teachers or more expert teachers by going beyond their formal personal knowledge that is subject knowledge. Bereiter and Scardamalia (1993) have also pointed out that, unless it becomes part of a person's

informal knowledge, formally acquired knowledge is not of much use. I concur with this as this also resonates with my story about teaching science as well as the stories of the three science teachers (a preschool, a primary, and a secondary) in Appleton's (1997) book 'Teaching Science Exploring the Issues.' The preschool teacher lacking confidence taught only about plants and animals using materials prepared by others or that had previously worked for her. One day a video on children engaged in doing and talking about the science of cells and simple circuits stimulated her. With her advisor's support and encouragement, she made conscious deliberations to change her practice. The primary teacher hated school science and found it boring, yet ended up being a science teacher, that too a 'specialist.' Added responsibility forced her to take deliberate action for her professional growth to have her students love doing science. The secondary teacher with strong science background and interested in science teaching, initially taught as he was taught. With time he pursued his professional growth by taking up leadership roles, through project, engaging in readings like PEEL works, and getting involved in collaborative research with university with his own students. These stories have much in common with those of my participants. I provided copies of these stories to them for two main reasons: Firstly, as a sample to write their own stories and secondly, to boost up their self-esteem. Teachers from countries like Pakistan tend to believe that it is only their knowledge and practice that is problematic. After reading the stories the participants had this to say "*wakyia hee hamari taraa aur teachers doosari countries main bhi hain ... yee bil kul hamaray teen ki tara hai*... (surprisingly enough there are teachers like us from other countries as well…these three teachers are very much like the three of us)."

The above descriptions of teachers' lived experiences and learnings, whether from Pakistan or Australia, or any other country for that matter, undoubtedly, have a strong message: 'to teach, one must know.' The question is 'what' or 'what knowledge do teachers necessarily need for teaching?' The voices of the teachers and my own personal and professional experiences clearly support the argument that subject knowledge by itself is inadequate especially bearing in mind the current trends and issues with emphasis on constructivism in the teaching and learning of science. This makes the teaching/learning process dynamic, complex and evolving. The teachers need to go

beyond mere personal knowledge about the subject or the discipline as the act of teaching implies transmission, translation, and more importantly transformation of knowledge from one person to another. It involves relationships. Osborne (1999) has helped me to articulate it:

> teaching, learning and science are fundamentally about relationships about people and between people and things. These relationships are developed, they change and evolve over time, as an interplay between those involved (both animate and inanimate), as each side of the relationship is affected by the other. (p. 227)

INSIGHTS GAINED FROM STORIES

As the stories of my participating teachers and of Appleton's teachers reveal, the relationships began and developed in their respective contextual realities with some assumptions and purposes (implicit or explicit) in mind. Of course, this did not happen in isolation but with support of colleagues/school administration, other information sources and opportunities to reconceptualize and test out ideas in practice. With time the individual teacher's relationships altered and challenged their assumptions and purposes that in turn changed and the direction of their thinking shifted. However, the purpose, level, depth, extent and detail differs across country, context, and level taught. This is not surprising from a constructivist point of view. Ausubel's (1963, p. 13) constructivist perspective is that the most important single factor influencing learning is "what he (the learner) already knows." Although this is predominately applied to the learners, I believe it is equally applicable to the teachers. Thus my partners have come aboard not as 'empty vessels'(Freire, 1970) or 'empty slates,' but with a substantial knowledge base about the teaching and learning of science beyond the subject knowledge that they have developed and constructed over a considerable amount of time, both personally and socially. They differ in their histories, the grade level taught, their level of thinking and reflecting, as well as their belief and personal attributes. My partners' stories and their responses to the focus questions (see appendix 2), and my own personal relation with the partners strengthened my underlying assumption that they (partners), at the start of the project are more inclined towards 'transformation' mode than 'transmission' mode of teaching. In their struggle to improve their practice, and in particular their pedagogical content knowledge, my partners have moved from a style of telling, lecture and teacher-centeredness to more activity based and student-centeredness. This is also supported by

Naqvi's (1999) research findings reported in her study 'Impact of Subject Specialist Teachers (SST) Program on the Teachers' Classroom Practice':

> The Subject Specialist Teachers had acquired significant learning during the SST program. As a result of that, they have significantly changed their classroom practice. It is evident from the observations that the classes are child-centered, and the teachers' role is that of a facilitator of students' learning. Moreover, the teachers are not worried about resources because they now use low-cost and no-cost materials. Consequently, the SSTs saw themselves in a more effective role, as less authoritative and more confident, in terms of their pedagogical content knowledge. (p. 50)

All three partners have diverse backgrounds and a wealth of personal and practical knowledge. Their strong desire for continuous growth has been influenced by their negative experiences. However, their struggle is on going. They are motivated, inspired, and determined to move on. These insights and the partners' reasons to learn more by coming aboard the project, made me realize the need for being sensitive to the diversity involved and, hence, to pay attention to individual concerns and aspirations over and above the project expectations in a collaborative effort.

Chapter 4
EXPLORATIONS

This chapter presents the enacted classroom practice of the research participants, and interactions between different stakeholders such as the heads and the principals at the start of the project's field based stage. During this stage, individual needs of the participants were identified by the participants themselves and, as a group; we established a common understanding about our way of working.

MY INITIAL CLASSROOM EXPERIENCES

To gain further insights into the participants' concerns about their practice and to help them articulate these, the first couple of classroom visits for each participant for the period September 27, 2000 to October 14, 2000 were negotiated during our first group session. It was mutually agreed that I (researcher) would play the role of an observer in a non-evaluative, but supportive manner so as to stimulate post lesson reflections, share thoughts and ideas, and articulate emerging questions and concerns. I would, then, work together with the participants to reflect, plan, and take more purposeful actions and simultaneously enable the participants to gain a sense of ownership. This was consistent with the participants' expectation as well:

> Saira, "I want to improve my personal growth and know how I can reflect myself. It will affect my teaching ... become more effective ... how can we observe our students and then how can we reflect on teaching." Nina and PT who were listening attentively ... *"yes."* (group session, September 15, 2000).

For more in-depth and insightful perspectives on pedagogical content knowledge, I think that reflection upon both the scientific concepts themselves and upon the general pedagogical aspects as projected by actions in the classroom is necessary. This is important as teaching involves setting goals and working towards them by reflecting upon both the goal and the process. This has been highlighted by Osborne (1999) as well, "teaching involves reaching toward a goal which in turn can cause reflection upon both the goal itself and the process" (p. 5). To develop my arguments and, thus, my understandings about the nature and level of pedagogical content knowledge of the individual partners I will draw upon, share, and discuss appropriate segments from

detailed descriptions of lessons, anecdotes, dialogues, artifacts and documents, and field notes. I will intersperse these with my interpretations.

CLASSROOM OBSERVATIONS

CASE ONE: PT

My first classroom observation on September 26, 2000 in class two and the talk thereafter surprised me and shook my image of the Subject Specialist Teacher's being an exemplary teacher. It put me in a dilemma. The lesson was from 9:00 am to 10:00 am and half an hour before that we had our pre-lesson talk. However, the school bell on this day was late by seven minutes and, hence, the lesson instead ended at 10:07 am. In addition to the participating teacher (PT), forty out of forty two students (all girls between 6-7 years old) and me, the participating teacher's co-teacher was also present on this day. I was given to understand that the co-teacher was new and had recent Visiting Teacher (VT) Program exposure from the Institute for Educational Development, taught another section of class II, and was expected to learn from PT. I reached PT's school at 8:30 am and found her waiting for me in the teachers' staff room, sitting beside one of the tables without any materials in her hand or on the table. There was hardly any other teacher in the staff room. With permission I took a seat next to PT and after a short pause I broke the silence (field observations and notes):

Pre-Lesson Talk

(Key: R for researcher; PT for the participating teacher)

R: Please tell me about your lesson.
PT: Materials have weight also I am going to teach mass.
R: What else would you like to tell me about?
PT: I will give them materials in groups so they will have to sort which can be measured in liters and which in grams. They will then write in copies.
R: Anything more you would like to tell me about your class. Other than what you are to teach.
PT: They are sitting in groups (quiet). (conversation transcript)

Further questioning and probing enabled me to gain more information from PT about the organization, expected nature, and delivery of science for classes one to three at her school and the school system as a whole. PT said:

> We have four centers English Language, Math, Urdu and General in four different classrooms and duration is one hour for each center. After each hour students exchange their centers, that is the whole class moves from one classroom to another. For classes one to three we teach Integrated Primary Curriculum using thematic approach and merge English Language, Social Studies, and Science concepts ... which subject is more addressed depends on the nature of the topic. We have previously prepared plans to follow on the themes: My Body, Food, and Homes for Term One; Matter and Forces for Term Two which is going on now; Energy and Earth and Universe for Term Three. (field notes and conversation transcript)

As our conversation continued, the following exchange ensued:

R: When you teach matter … Like you are to do today … Do you make links with previous term's … that is First Term's … topics?
PT: Yes, Food.
R: Can you give me an example?
PT: The activity I am going to give has wrappers e.g. chips, biscuits … they will have to find out which of these things will have to be measured in grams and milliliters. I am going to give them cans e.g. coca cola, small juice bottles.
R: Any other way in which you will make connection with Food?
PT: No, today I am to do only this. (conversation transcript)

We were conscious of the time. By now it was 8:50 am and in ten minutes the lesson was expected to start. PT excused herself, got up and moved to a cupboard on one side of the staff room … picked up some things in a plastic bag ... looked at me and said, "Let's go." Just as we approached the staff room entrance ... the Head and the Deputy Head passed by the staff room on their regular routine round of the classes/school. (I learnt that this is a daily routine where heads walk through the hallways and corridors to make school rounds. They sometimes decide to step into a class to observe). They stopped momentarily, greeted us and, with smiling faces, said "welcome" to me and moved on (field observations and notes).

Classroom Experiences

We made it to the class on time. The change of class took about seven minutes and by the time the students had somewhat settled down it was 9:15 am. The lesson ended at 10:07 am. Throughout the lesson I did not notice the teacher referring to any notes or lesson plan. The lesson began with recall of the text-book definition of matter 'matter has mass and occupies space' (field observations/notes): (Key: S1, S2 … represent individual student; SS represent all students and PT represents the teacher)

PT: Tell me what is matter?
S1: There are three states of matter.
PT: I have not asked about states…
S2: Miss, anything that is like stone.
PT: (no response to the student S2's answer) anything that has … (expecting students to respond … students quiet or some talking) what it has … Sara, what it has … (no response from Sara) … Anything which has mass and occupies space … now say together …
PT and SS: (in chorus) anything that has mass and occupies space (repeat a couple of times).
PT: What are three states of matter?
SS: (almost all in chorus) Solid, liquid and gas.
PT: (repeats) Solid, liquid and gas … can you give me example? (lesson transcript)

PT is at the chalk board, most of the time facing the chalkboard. Many voices … hard to hear anything distinctly, students at the back of the class near me (R) seen doing their own things … busy talking … PT writes on chalkboard: Solid Liquid Gas … walks to a student in front close by ... (field observations and notes)

S3: Sui Gas (local name for methane gas used as energy source by most households).
PT: Very good (goes back to chalkboard writes 'Sui Gas' under 'Gas' and writes some own examples under 'Solid' and 'Liquids' and then erases everything). (lesson transcript)

It is five minutes into the lesson … mostly the teacher talks and that too fast and expects quick standard answers. Mostly students closer to teacher's table just in front of the classroom seen paying some attention rest doing own things … looking around, fidgeting, or just sitting idle … In similar manner, for the next seven minutes students are asked 'what' and 'when' questions about shopping apples and milk and teacher manages few students to say apples 'we buy in kilo' and 'milk in liters.' Simultaneously keeps writing and erasing on board. Finally PT makes two columns: kilogram/gram/milligram/pau and liter/milliliter as headings (note: 'pau' is a local unit for 250 grams) and then suddenly turns to the class and 'now I will give … you (students) will have to be careful …' leans over a table by the chalkboard, picks up plastic bags with stuff in … co-teacher who had been standing in the front left corner of the class all this time helps to pass the bags … teacher randomly gives away items (including sheets of paper to write on) tied in plastic bags or loosely … students start talking, reaching for items or almost snatching items … some girls hold on to items for themselves … noise

level goes up … teacher mostly stays in front of the class with one group in particular, facing away from the rest of the class … for the next fifteen to twenty minutes there is commotion in the class ... most of the time students are unsure as to what to do or perhaps just seem to seek teachers consent. Students are heard asking questions but mostly low level 'what is this … thing? What to write? Where to write this?' Or reporting what the other student has written. Teacher responds now and then and that too by 'telling' rather than stimulating discussion. Teacher's questions are mostly low level 'what' 'where' type, though 'why' was heard at times, but these were inadequately capitalized upon for purposes of making students think or to get a satisfactory answer ... PT finally comes to the students at the table next to me (R) and talks to the students (field observations and notes):

S1: (pointing at the tape recorder) Teacher what is this?
PT: You are not to touch it. It is not your thing. (Students are curious and trying to touch the tape recorder) … Don't touch it. It is not your thing. (In firm voice) It is not your thing … okay. (Another student diverted teacher's attention … but S1 in the middle of teacher and this other student's talk comes back …)
S1: Teacher what is this thing? What is this thing?
S2: This is tape recorder.
S1: Why is tape recorder set-up?
S2: To see if it is heavy or light.
S1: Why is it on? (lesson transcript)

PT did not respond to this … maybe because only ten minutes remained of the lesson and teacher still had to do conclusion and give copy work … I (R) who had no intent to say anything, silently debated whether it was appropriate for the sake of the child to say something or not. Observing S1's mind was stuck on the presence of tape recorder and since I (R) had placed it there, I felt it my responsibility to break the silence with PT's permission … (field observations and notes):

R: (bearing in mind PT wants to move onto conclusion) Listen (getting closer to S1), why don't you finish your work first then I will tell you (this seemed to have worked … and before leaving, I made it a point to tell S1 that the tape recorder I had placed to record the talk lest I forget what they said. I do not have a good memory. S1 smiled and said okay… smiled again and left). (field observations/notes)

Students seemed to have difficulty in a) knowing what to do, b) reading and writing words, and c) understanding concepts. The student-teacher talk was mostly playing a guessing game as this transcript segment suggests: (Key: PT for teacher; S1, S2 ... for students)

PT: (pointing at a student's work) this one here … write 'coca cola' … what is this that you have written … (picks up a coca cola can).
S3: (pointing at a writing on the can) This here is it's name.
PT: Read it.
S3: Ko … kaa … ko … ka.
S4: Teacher this (meaning the word coca cola) should come up here (unlike most of the other students, this student had divided the page into two columns by drawing a straight line right across the middle of the page widthwise. 'Up' meant top have of the page).
PT: Why should it go up there?
PT: (mixed voices of students…can only pick up some words …) ko … ka … teacher … ko … teacher … will go up (meaning top half of the page) …
PT: Why would it be up?
S4: Teacher it has air … air is in it …
PT: What comes in it?
S4: Yes, liquid comes in it.
PT: Yes.
S3: Teacher solid … solid … Yes.
S4: Gee … ram (attempting to read the word 'gram').
PT: Yes, it will come under 'gram'. Very good. (lesson transcript/field notes: for sample transcript see Appendix 2)

The last ten minutes were mostly spent in teacher trying to manage the restless class and in the process getting frustrated. Ten minutes to go for students' snack break to be followed by school recess … noise level has risen … materials are still on the tables or some on the floor … teacher is trying to get students' attention … it is not working … suddenly … (field observations/notes)

PT: (almost shouting) Now girls … now girls … what have you written? Say your answers … (turns around faces the chalk board and the students sitting on her right in front…) under the column 'Kilogram/gram' ... (only the students in front get attention and make a few contributions ... rest of the students either moving around, talking or fighting … for the Litre/millilitre column teacher, herself, hurriedly entered five items … only four minutes to go … in an angry loud voice) I want you all to stop … please bring all the things (only some students in front responded and walked up to hand some items … co-teacher and teacher move around to collect items … trying to settle the restless students eagerly waiting for the bell to ring …). (lesson transcript/field notes)

My Personal Post-Lesson Reflections

Much happened in the forty-five minute lesson. However, there were discrepancies in a) the teacher's theoretical perspective and actual practice and b) the objectives shared before the lesson and what was actually taught in class. Why these discrepancies? My immediate thoughts after the lesson were not to draw any conclusions or judgments, but to stop, think, and reflect. I found it hard to keep up with the pace of the lesson. Moreover, it was difficult to keep up with the teacher switching back and forth between English and an immediate translation into Urdu or vice a versa without any wait time. I wondered how much the students were able to follow and learn, particularly the concepts of 'weight' and 'mass' as intended by the teacher. I also questioned how many students were really reached? I had observed that after a quick review, rather mere recall, of a text book definition of 'matter' and stating the three states of matter, the students were required to categorize the given samples of empty wrappings, cans, tubes and bottles (some bottles were not quite empty, so students out of curiosity sprayed stuff at each other, poured, played with and tested the contents … well they had inadequate instructions generally about safety or precautions in particular) into two columns: Kilogram/gram and litre/millilitre by reading the name of the item and whatever unit was shown on the containers. The students seemed confused and uncertain as to what they were expected to do. The teacher went around during the small group activity 'to sort given items' repeating the same instructions most of the time and 'telling' rather than stimulating discussion. Beforehand, I had learnt that the lesson was about weight and mass in materials. However, the lesson ended abruptly at about 10:07 am (The bell rung late on this day – at 10:07 a.m. instead of 9:58 a.m.). The students became impatient and the teacher and co-teacher struggled to keep them in their seats and stay silent. The contribution for the column 'kilogram/gram' was completed only by a handful of students. The teacher hurriedly told the students what to fill in for the column 'litre/millilitre.' Only a few students managed to write one or two items of this information on their sheets; a handful of them had made only columns with headings. I wonder why all this is happening? Hopefully, I will get some answers to my questions from our post-lesson talk and I will learn more about what was happening and perhaps

why and what can be done? I am eager to meet with the teacher and learn more (personal after lesson reflection Charan).

Post-Lesson Talk

PT teaches only the morning session and usually goes home as soon as school ends at 12:30 pm. However, with her family's permission, she preferred to meet me on a one-to-one basis just after school. The two of us met in a quiet room:

R: How do you feel about your lesson today?
PT: No.... (pause).
R: Try to think.
PT: I think I have forgotten to explain to them (students) about mass.
R: When do you think you would have done that explaining?
PT: In motivation during explanation ... just after motivation. Then I should have told them mass we measure in ... if solids in kilogram and if liquid then in liters. (misconception in unit of mass)
R: Anything else you can think of?
PT: No, after that it was that activity that was done.
R: Anything more ...
PT: No, I am satisfied.
R: (needed to think of an alternative to have teacher's input) Suppose you were to sit down quietly and think back to recollect your today's lesson, would you be able to describe events and talks with your students from the beginning to the end of your lesson?
PT: (no response ... blank expression ... 'R' waited...). (conversation transcript)

I was stuck. I needed to think of and suggest some other alternative to avoid 'telling,' but helping the participant to reflect more upon the lesson herself. In our pre-lesson talk PT had mentioned teaching a parallel lesson the following day. This gave me the idea of suggesting that we videotape the next day's lesson with the intention that both of us view it independently and then compare our notes and discuss. It also seemed to me that a videotape would serve to give us evidence or clarification in case there was any discrepancy in our notes. To my surprise she immediately agreed to this. PT said, "(It) would be interesting. Let us see how one can remember things." We discussed the ethical considerations around videotaping her lesson. What surprised, yet delighted, me the most was that my participant agreed to write about her lesson towards the end of our discussion: "I shall try to write about my today's lesson." My reflection on this reminded me of an excerpt of a publication by Katz (1993) 'Helping Others with Their

Teaching: General Techniques for Working with Teachers' under the section 'Phrase Suggestions in Experimental Form.' Katz (1993) reasons:

> that when suggestions are made in terms of what to try "next time," the likelihood of humiliating or embarrassing the teacher about the incident just observed is minimized. Some in-service educators are so eager to get teachers to analyze their own "mistakes" following an unsuccessful teaching episode that they might inadvertently embarrass them, which in turn could undermine the teachers' dispositions to go on learning, trying, inventing, and seeking the best methods for themselves. (p. 2)

With this concrete experience it made more sense to me.

Later in the afternoon, with PT's knowledge, I negotiated with her head a written permission (see Appendices C and D) to record her lesson. During my conversation with the head, I unconsciously signaled an unintended message to her: (Key: H is for head; R for researcher)

R: We, that is PT and I, have agreed to video tomorrow's lesson. We would like to get your written permission too. We would like to try using a video to observe the lesson, reflect and then plan our actions accordingly.

H: (immediately in a surprised voice) Did you find problem with PT?
I was astonished to hear this and taken aback. This particular head has been active participant in the Institute for Educational Development head's seminars for a number of years, has an Advanced Diploma in School Management from the Institute for Educational Development, and a research experience. I became quiet for some moments … I needed to clarify my intent…

R: I did not mean that … also my intent is not to evaluate but to support and work with the teacher. Videoing will make it possible to capture not only sound but body language and children's work too. So we can observe more details and if in doubt playback and discuss. It will be only for PT and my use unless PT decides otherwise.

H: Okay, okay… it is lucky for teachers to have people like you to work with. They will learn more.

R: Thank you. I will learn too. (field obsevations/notes)

This anecdote taught me to be mindful and tactful when interacting with other stakeholders at the school so as to avoid causing unnecessary conflict unintentionally. The head's support to me was most desired and welcome. I shared my experiences of the day and how I had to, in collaboration with the participating teacher and her school head, plan and act to videotape the teacher's parallel lesson with my institution's director. His response was, "It is important that they are willing to engage with you." Indeed I realized

this too. With all the administrative dealings about videoing in place, I anxiously waited for the next day's lesson. I also became curious about the two other initial classroom visits scheduled for the week. Though I had gained insights from what I had heard so far about the beliefs and teaching/learning perspectives of the other two participants as well, the nature of their classroom practice still remained unpredictable for me.

My Interpretations of PT's Reflections

Journal Entry: PT's own description of the lesson of September 27, 2000 concurred with my observations (see Appendix 3). Her reflection on our post lesson talk drew my attention to the difficult and time consuming task of a teacher attending to what children say and then trying to revisit it and reflect upon it. PT's lesson description is predominantly a reflection of what the teacher 'said and did.' That is to say, the focus is more on the teacher. However, as for videoing the lesson, she had mixed feelings "most probably they (children) will not be active because of video camera ... I am not sure about it. Let us see what happens tomorrow." Inherent in this concern of the teacher, I see her belief that children should be 'active.' However, I question her notion of 'active.' To me it seems to be at variance with 'active learning.' It is a likely area to consider. PT raised further ethical questions for me, "How will the confidentiality of video be kept? Will it be shown to the other teachers?" Though we had discussed it the previous day, I still felt obliged to reassure her that it is my responsibility to keep it just between the two of us and that, once my thesis is written, I will destroy it unless she decides otherwise. I reminded her of the mutual written consent as well. In spite of all the questions, we ventured into the act of videoing the parallel lesson on September 27, 2000. At the start of the lesson, PT asked me to introduce myself to the class and, with her permission; I introduced the camera person to the class as well. I thought the students might ask 'why are we videotaping the lesson?" However, they did not. I did decide to tell them that the camera man had come to take a video of the class. I explained to them that he would do his work and we would carry on with the lesson and not worry about him. The students listened to my explanation and some of them smiled. As soon as PT began the lesson, they were not even bothered by the camera man's presence. My overall comment for the lesson read as follows:

> today's parallel lesson was pretty much the same as yesterday's except that teacher spent somewhat more time collecting examples of solids and liquids from students before starting the activity, gave more explicit instructions especially for grouping and social skills before distributing materials and at the end had input for items listed at least one from each group. (field notes Charan September 27, 2000)

My field notes of the day's lesson were pretty close to those of PT's observations. She had also noticed that, once the students got into the activity, they were not bothered about the camera (see Appendix 3). She had an opportunity to test her hypothesis and change her thinking. Nonetheless, it is worth noting that the 'sameness' of the two lessons in my field notes and that of PT's journal entries do not carry the same meaning. My 'sameness,' unlike PT's, includes the discrepancies as well. We still needed to engage in a conversation after viewing the video. For the convenience of both of us, October 2, 2000 seemed the best day.

Video Watching: The process of dialoguing, convincing, negotiating, and making appropriate and timely arrangements for making a video finally enabled PT to change her thinking. The willingness of the participating teacher and the head was also necessary and responsible for this change to happen. The change was from 'I am satisfied' to self identification and realization of four problematic areas:

a) questions … questions … that students were not quite comprehending. For example when I (PT) asked them, 'how much mass has the matter?' and 'how can we measure it?'

b) other problem … when I gave them the shopping bag with materials, they (students) started quarrelling with each other and there was a problem in controlling them.

c) when I asked them to 'drop the pencils' (seemed a strategy or a rule, one of the few rules in class, which this teacher used to get student attention) still some girls were not listening and I had to interrupt the conclusion and go there to draw their attention … to ask them to drop their pencils.

d) finally, when I asked them to collect the things, they again started quarrelling with each other. (conversation transcript after viewing video September 27, 2000)

Interestingly enough, during the course of the conversation, a moment after articulating the above four problems, the teacher switched back to 'I am satisfied' (conversation transcript September 27, 2000). However, the teacher's own formulation

of some of the problems helped me (R) to challenge the teacher and to reconsider her thinking. This further helped the teacher to, admit to and give reasons for her anger:

PT: Teacher (meaning herself) gets angry easily. Teacher has much anger inside.
R: Why would that be?
PT: I don't know.
R: Let us go back to the video ... when did you get angry?
PT: When students were working in groups ... and when I asked them to drop their pencils ... this is when I get really angry but I do try to control ... also when students were talking very loudly. (conversation transcript Sept. 27, 2000)

Though the teacher picked up questioning and social skills as areas of concern, the discrepancy between her conceptual understanding of the subject knowledge and the children's ideas still went unnoticed by her. However, the flow of the dialogue gave me a natural lead into probing, discussing, and informing her about the understanding of science concepts involved; namely mass, volume, the units in which these are measured, and that water is a special liquid for which one kilogram of it happens to have a volume of one litre. Thus, though one may measure the volume of water in litres one may state the amount as one kilo of water. This, however, does not work for all other liquids, for example milk. Amounts of solids in the SI-system are normally measured in kilograms, grams, and milligrams and amounts of liquids are commonly measured in litres and millilitres. At this point I thought it appropriate to share some of my observations about the children's ideas:

> I noticed specifically on two occasions during the first lesson that girls when sorting items were thinking ahead and questioning; first time in the case of empty Coca Cola can a group of girls wanted to write under 'liter/milliliter' because they said it had air in it ... I thought it was clever thinking. Air, a gas, comes under fluids (liquids and gases). For this group of girls it seemed air was more like liquid than solid and it fits in the liter/milliliter column ... and it was a sensible choice. I think they were making sense too. The second one was case of Colgate Tooth Paste. Girls seemed to be debating where to place it, one girl even said 'gas.' From the looks and feel tooth paste is not quite like solid nor liquid. Unfortunately it has been a tradition to think that things can be categorized in three clear cut states. However, some things do become problematic e.g. toothpaste. I was amazed that the girls seemed to have thought about it. I also thought since some of the tubes of toothpaste had 'mL' as unit, girls seemed to have inferred it as a liquid. Children bring their own knowledge to the class and activity. This reminds me of one other moment in the second lesson when girls were asked 'what do you say when you go to buy milk?' Some girls responded 'Give me one kilo milk' which was not the answer you had expected. The shopkeeper near my place sells milk by kilos. I feel these girls probably had that experience. I find it really interesting how students come up with unexpected answers. It does indeed make teaching challenging at the same time interesting. (conversation transcript Sept. 27, 2000)

Our discussion after having videotaped the lesson 'clicked' a turning point in my participating teacher's thinking. Yet I was concerned:

> Though I sense a turning point in PT's thinking after today's talk, I worry about PT's words 'teacher has much anger inside her.' I need to pay attention to and be sensitive to this and not press her as I proceed to work with PT for the rest of the project unless in anyways it will happen to affect professionally. (Charan's Journal Entry October 2, 2000)

At the end of the session, PT's response to my request for the lesson plans of the two lessons that I had observed, the children's work, and a suitable day and time for sharing the planning of the next lesson was, 'lesson is the same that was taught to both the sections … give me time. Children's work … needs time … two to three days. Call after 9:00 pm for day ... because I need time with my daughter before that.' I was pleased that PT did not just accept my request, but expressed her requirements as well.

The use of the telephone was another one of our 'cultural changes.' Strangers' telephoning individuals, especially females, and that too for work related reasons, is not a culture of the context as I will share as anecdotal evidence later on. However, from the very beginning of the project, Saira and Nina felt it a good idea to make use of this means of communication. This was agreeable to PT, but only after 9:00 p.m. Following up on this, I felt it wise to request the participants to prepare their family members about this. This they did willingly and promptly. As a result, I also came to be known as 'Charan' to their families.

CASE TWO: SAIRA

On September 20, 2000, a week before Saira's classroom observation, I visited her school. She shared her Weekly Workload Schedule, Term wise Syllabus for Class V, the prescribed text book, 'Oxford Primary Science Book 5,' and a sample lesson plan from the Unit 'OURSELVES.' She had also done more work on the focused questions. Saira as a person and these materials served as the focal points for our conversation. This is illustrated by the following segment from our discussion (field observation and notes): (Key: Saira for the participating teacher; R for the researcher)

Saira: My lesson plan has these sections (points at the three columns; Student, Teacher, and Resources)

R: (pointing at 'Teacher' column) so you start the lesson by ... (immediately Saira carries on).

Saira: By asking questions ... actually it varies ... depending on topic ... sometimes questions ... sometimes activity ... sometimes worksheet. In every lesson I also mention process ... skill ... which skill/s I want to develop in the students ... for example in this lesson I have: identify, labeling, drawing, discussion, writing, involving. (conversation transcript)

Saira's lesson plan reflected an inclination towards a student-oriented approach and learning by sharing and doing individually, with the whole class, and in small groups. From our subsequent talk, I learnt more from Saira about her practice and related aspects that further support her knowledge about the nature of science, resources, her students' understanding, and her collegial relationship with her colleagues:

> I very much like this area 'Things to Do' of this book at the end of every chapter, because it helps the students ... creates interest among students. They are mentally prepared for the coming lesson/ new topic. ... like in this topic 'food' when they will come to their next class they already have a prepared 'meal chart' with them ... whatever they are taking in their different meals and they can then easily share with the class. They also bring different information about the different areas from different medias and I then put this information in their portfolio files. This textbook ... students also have it. I have also the teacher's guide for this book for my reference. So students have book, so they can easily do 'Things To Do.'
>
> Nowadays our students have (pause … as if looking for a word) improved little bit their English language and they can more easily read it but I don't think that they are reading with an understanding … sometimes when they don't understand they (with stress) ask me… they ask me about whatever they have written or cannot understand, so I help them and tell them. It is not necessary that we get 100% response of these things from all students … it is possible some of the students cannot do it … but I guide them ... difficult words like 'pasteurization' I explain them because this word is also over there (turning to previous page) 'what is the meaning of pasteurization?' … so I bring in different materials which are related with daily life and discuss what happens and how we can preserve food in different ways.
>
> I had prepared my lessons before the second term started. I leave my lesson plans for the other teachers especially new and inexperienced to ... look at or use and learn ... sometimes we share our lesson plans in a group on Saturdays ... we share ideas and activities and learn from experienced teachers ... some Saturdays we do purchasing of teaching aids/resources ... (Individual dialogue Saira and Charan September 20, 2000)

My interaction with Saira and her documents made me more knowledgeable about her. I perceived her to be a keen teacher who is genuinely interested in transforming her subject knowledge to make it more interesting and related to the students' daily life experiences through a variety of instructional strategies. She plans in advance and shares her plans and knowledge with her colleagues; she also learns from them. Though she had

a reasonably detailed lesson plan as a subset of her Unit Plan 'OURSELVES' with the main elements of the lesson written out, it still remained a suspense for me to see this lesson plan in action. From my experiences, personal and working with other teachers, I had a feeling that there was a lot more in the plan than is normally possible to accomplish effectively in a one hour period. Also, I wondered how it would work out since English was going to be used as the language for instruction and I was unsure how much the students would comprehend. I refrained from making any comments regarding these aspects so as not to influence my initial exploratory observations. I had to wait and experience the reality of a plan in action on September 27, 2000 from 1:10 p.m. to 2:10 p.m. and, thereafter, Saira's reflection on the lesson so that we could begin to pursue our work in the problematic areas identified by Saira herself.

Pre-Lesson Talk

Today, September 27, 2000, I arrived at Saira's school at about 13:00 as we had agreed. I met Saira waiting for me in her Primary Section's School head's office. Saira had identified this as our usual meeting place at her school (field notes):

> I met Saira ready to receive me in her Head's Office. Her head has ... an open door policy and also has a corner in own office ... for meeting with teachers socially or formally. This I had witnessed since my April 2000 visits and I had to clarify with Saira if she felt comfortable having our meetings there as she had suggested. Her response was, "My head has no objection and I don't mind. At our school we like to share. If we need or head needs the room we can always go to my science room or any other free room." This was our understanding. (Charan's field notes September 20, 2000)

Once again she had her books and lesson plan with her. She shared her Lesson Plan Three from the same unit, as mentioned above, on the topic of 'Preservation of Food.' Making reference to the lesson plan she said, "Here is my lesson plan. Yesterday I took it home, and made modifications from my previous flaws." Saira then shared the objectives, motivation activity that incorporated a review of the previous lesson, and her sequence of the lesson development with me. Towards the end of our brief talk, a significant moment, which drew my attention to Saira's special attribute, occurred; Saira responded positively to my request to use an audio recorder during the lesson:

> Yes, you can use ... I cannot afford a recorder (in a disappointed voice). But it is always my desire to record and listen to my lesson and reflect on my language use ... my temper (stresses and laughs) when students don't listen to me. (field notes)

I had intended to make copies of the audio tapes for the participating teachers, and this anecdote naturally paved the way for me to make the offer. Saira, herself, expressed her desire and she was, therefore, able to borrow her lesson or talk tapes as and when she wished. She did make use of this opportunity to get feedback during the project, especially at the beginning. She did not do it all the time because it was time consuming. The other two participants were also encouraged to listen to their respective tapes by making appropriate arrangements either at the Institute for Educational Development, before or just after our group sessions, or at home. In fact, two of them even had copies made of some selected tapes for themselves and took the responsibility of maintaining confidentiality.

Classroom Experiences

At 13:10, we entered the Primary Science Lab which Saira has, over the past years, equipped, organized, and set-up with posters, displays, and science models like stuffed local birds and some small animals. The students (all boys, age range 11-12 years) were already in class. Some of them were sitting on chairs around six hexagonal student tables, some were moving around, and some were busy talking. I walked in quietly and as discreetly as possible and sat down on one of the free student chairs at the back of the class. The students nearby noticed me and greeted me with a smile. I greeted them too. On this day, 39 out of 43 students were present. Saira greeted the students and asked them to settle down by saying "are you all with me, I need your full attention." Most of the students settled down and Saira immediately commenced the lesson with "first I will tell you what we will do today." She shared the lesson objectives and the plan for the lesson for the first 11 minutes (field observations/notes):

a) Lesson objectives: to write the ways of preservation of food; to know the names of germs and infections they cause.

b) Lesson planning: sharing 'Home Fun' (motivational activity); Discussion 'checking your previous knowledge' of food samples and questions; Reading task; sharing reading with class; Conclusion.

She then followed the order of events in an interactive mode which reflected a reasonably good blend of content and pedagogy, as per her lesson plan. She used a variety of strategies: student group presentations of 'Home Fun' task on 'how flies carry germs from the environment and to humans;' displays of food items to discuss ways of preserving foods namely chemical, pasteurization and sterilization; individual student reading tasks about food preservation methods, germs and the infections they cause; and students sharing, discussing their learnings from the 'reading text' task, and linking it to the previous topic 'hygienic habits' which they had studied. Finally the teacher assigned the students two home tasks; 'Make a List of Hygienic Habits' and 'When you go home find out whatever foods you have at home and in what ways they are preserved.' The lesson ended at 14:05, five minutes after bell rang (field observations/notes).

How the lesson developed in between is lengthy and insightful in terms of the struggles of an enthusiastic teacher attempting to teach an interactive and active approach in English and in a large class. English as a medium of instruction is a challenge for both the teachers and the students in Pakistan. The transcript of this lesson was about thirty double-spaced pages, excluding parts of the lesson that were unclear or not captured in the recorder. This gives some indication of a lot of 'talk,' predominantly 'teacher talk' (often switching back and forth between English and Urdu or translating from one language to the other). The pace of the lesson was fast, particularly during the latter half of the lesson to make up for the extra time taken when sharing objectives and delivering the first two items of lesson plan. Saira's description of the situation was, "time is a constraint, I rushed and thus let only the intelligent students to answer" (Entry in Saira's Grid for Lesson September 27, 2000). Here I will share only significant segments of the transcript to highlight the nature of the struggles and challenges, both for the teacher and the students.

For reasons of inconsistent rules and social skills, dual language usage, interjections, and interruptions from a small group of students, the teacher lost class time and faced discipline problems: (Key: Saira for teacher; S1, S2, ... for different students; SS for students)

Saira: After sharing what will we do?
S_1: Discussion of foods.

Saira: Okay, different food samples I have put in front here (pointing to her display table on which samples of foods that she had brought from home were displayed, table was low so from back where I was sitting could not see much) for you. What is to be done now? ... (students start to talk amongst themselves)

S2: Discussion of food. (noise level goes a bit down).

Saira: Of food samples ... or your ... or teacher will ask you some questions about your previous knowledge (most students listened quietly for a while ... and then suddenly) ...

SS: (In chorus jumbled voices) ... 'Previous knowledge'... 'Take care of your ... your body ...' (teacher's eyes wandered across class room ... momentarily became quiet ... then) ...

Saira: Okay (class quietens) after that I will give you a task. You will do your task either within the time. I will tell you the time and yes what we will be doing ... (interruption from a small group of students) ... okay I want your attention ... do you remember your social skills? ...

SS: (in chorus) ... Yesss... Yesss.

Saira: I am talking to you, I am telling you something, I want your full attention with me ... okay ... and whenever you will talk (stresses a bit) I will listen to you. (Students become quiet and look to the front of the class, though a few are seen looking around now and then ... Saira grapples for another five to seven minutes with classroom management and sharing of objectives and eventually decides to write them down on the chalkboard) ... (lesson transcript/field notes)

Like PT, this teacher also encountered English language reading and speaking problems with her students. She struggled to orchestrate discussion and maintain a good pace and flow of the lesson. Her attempt to help her students learn to pronounce big and multisyllabic words took up extra class time. As a result, the teacher rushed and talked most of the time to complete the planned lesson. Consequently, the students' participation and science learning became restricted:

Saira: Okay ... sometimes we also preserve the food for long time by packing in the tin boxes ... (showing pop can) just like this tin box and in this way we also preserve it. *Tuo koi dhino kay baad bhi* cheese *khani ho tuo es ko hum* ... (so if we have to eat things after some day then we ...). This process is called sterilized. We can get our foods free from germs (coming closer to a student) *kuuch kahna chaa rahai ho* ... (Do you wish to say something?).
(Student response was difficult to hear or recor)...

Saira: Germs can be enter in the box ... okay ... *Jaab hum phasala karain tuo uus kay baad yaad karain* (when we have decided, after that remember) and one more thing *kay shoroo main hamara* discussion *chala thaa kay* (earlier we had discussion that) we have to read the date *tikh haay* ... *humay agar* date *padh laye hai tuo* expire *hoo jay gi tu woo* food *aab khanay kai kabil nahi haa*. (If we have read the date and it has expired then that food is not good for us to eat). *Lakin* (But) some foods can be saved by for the long time by another process which is

called sterilized. What is the spelling of sterilized? (immediately calls upon a student S1).

S1: S t e

Saira: Okay

S1: er

Sk: er

S1: il

Saira: il

S1: ized

Saira: ized, sterilized. *Yani* (that is) that means *kay woo ju* tin *kay* box *main hamara* food *atta hai jisay hum* germs *say* ... *Kaar saktay hain* (that food of ours that comes in tin or box and we can ... it from germs) ... that (a student is saying something) means you are not listening to me (students still talking; Saira is now bit angry) what's wrong with you (a student is coughing) okay so second way of food preservation is a sterilize and another way is ... *eek aur* (one other) way *joo aap ki* text *main* (which is in your text) mention *kiyaa hai* ... (is mentioned) *Jis nay* text *khoor say padha hoo gay uus koo pata hoga kaa ek aur* way *jo yahan* mention *kara hai*, (Only the ones who have read the text carefully will be knowing one more way mentioned there ...) (calls upon another student S2 ... but many students start speaking) miss chemical ... chemical ... physical ... (another student, loud and fast) chemical, physical, pesticides ... chemical.

Saira: Okay (firmly ... and writes on chalkboard) Chemical ... (student keep speaking) shhhh ... Chemical ... shhhh. (lesson transcript/field notes)

Likewise, the students and the teacher struggled with the talk about two other methods of food preservation, namely 'chemical preservation' and 'pasteurization.'

Post-Lesson Talk

Immediately after the lesson, unlike PT, Saira initiated the talk by sharing her reflection of the lesson. Then, I shared my observations: (Key: Saira for Saira and R for researcher)

Saira: Time is constraint … I had to achieve all the objectives … I could not … reading process for the students is problem … all students could not give full attention … some got it but most did not get … time is a problem, discussion in some things becomes long … and planning could not be completed on time … so could not give enough time for reading. Students wanted to give answers … but some couldn't. Students some of them are not interested in reading and I try to give incentives. In other lessons I give incentives like stars … today I did not, I forgot. So I am thinking how to create interest in them in reading. Also syllabus is a problem … some discussions become long and we rush to complete the syllabus.

R: ... some of the areas needing attention you have ... identified. What you might want to do until ... we meet for our second group session spend some more time to

> revisit your today's lesson in terms of questions like: What did I want to teach? Did students learn? How many? How do I know? If not, why not? If yes, what helped? ... What can I do to make some changes? ... we can arrange some other convenient time to meet and discuss and work together for the upcoming lessons. I will make a copy of the tape for you as well to listen to and reflect. (conversation transcript/field notes)

Saira had spelled out her concerns herself which eased me into a natural start of working together with her in a purposeful way for the up-coming period of the project. Saira's lesson of this day was more to facilitate information collection as well as to share and attempt to orchestrate small group and whole class dynamics for which Saira raised questions. The nature of this lesson did not offer me an opportunity to get much insight into Saira's conceptual understanding of science concepts per se nor did Saira say anything about it. However, she did demonstrate having knowledge about her students, the pedagogy, and the topic being taught. She was/is perceptive to and open to reflecting upon her practice. However, the two aspects that I thought she did not make explicit (perhaps these were implied in 'time is constraint' and 'discussion becomes long') were inherent in the medium of instruction, English, and the process of preparing and planning of tasks. Since they were not stated by Saira, I did not deem it wise to address them at this stage with the assumption that, as we work together, these will recur and at appropriate times and situations it will make more sense to probe further into them. Besides Saira was still to listen to and reflect upon the audio tape. This experience highlighted and reinforced my belief of the complex and unpredictable nature of teaching when approached from the perspective of pedagogical content knowledge. Even though the teacher had/s experience of teaching at this class level for a number of years and in a variety of ways, there still remains, as Saira indicated, much to learn from new experiences. It exposed me to the under layers of the inherent pedagogical content knowledge problems that even an experienced teacher can encounter and grapple with. I appreciated the challenges of this teacher. I waited in anticipation for my next visit to the third participant, in particular, her exploratory classroom observation.

CASE THREE: NINA

Pre-Lesson Talk

Although all our plans for Nina's exploratory classroom visit were in place, I arrived at her school at about 10:45 am on the morning of September 29, 2000 to find that the Cambridge Section classes were cancelled in celebration of a cultural and religious occasion called Milad. Nina was disappointed:

> I came quite early so that I could arrange a few things. When I came out for the assembly, I saw no Cambridge Class students. … A teacher asked me, are you dressed up for the Milad?" I said, "no I have got a class in Cambridge Section, I didn't know that there is a Milad!" I rushed towards the Cambridge Section and nobody was there. I told the peon, "please next time just come and inform me … see my class was going to be held... and she (R) is coming from Aga Khan Institute … from so far away just for the observation of my class. She is going to waste such a lot of her time over here …" I had also informed the chaukidar at the gate to let you (R) come in. (Nina: conversation September 29, 2000)

A committed and motivated Nina was to teach her first activity based lesson to the newly assigned Cambridge Class Ten on this day. She had planned, prepared, and organized this lesson under a number of other expectations and constraints. It was no wonder that she was disappointed:

> When I was just going to sit for planning my lesson, my son's mother-in-law came to visit with me nearly until 7:30 pm. As she left, I went and had all the photocopies made for the activity work ...I came home my servant also helped me. He was sitting with me making all those cuttings with whatever explanations I gave him. As I was doing that, suddenly the electricity went off. I took my battery tube lights and in that little light both of us were doing the work. The younger son of mine visiting me from Indonesia says, 'mother is all the time busy. I think she is more busy than Bill Clinton (laughs) because whenever we come home she doesn't have any time ... she is always sitting and doing work either for the school or for the Aga Khan Institute. Just then the light came and I think I was up till 12:30... once everything was arranged and put in the envelops, I said all my prayers which were left because I couldn't offer them during the specific timings … as I went to school. In the morning I got up early again it was needed ... I was quite satisfied that everything is ready for my first chance with the O-Levels Cambridge class to do activities. The students haven't been doing the type of activity work I planned. They do practical work but activity work they haven't done. (Nina: Conversation September 29, 2000)

A Change in Plan

Nina sounded very apologetic for not being able to inform me about the change and almost felt guilty that my (R's) time was wasted. She wanted to talk about her feelings and her plan. I empathized with Nina and, with her permission, I decided to stay on and listen to her describe what she had planned to teach and how she was going to do it. Nina appreciated this, "I am glad … this has given us opportunity and time to talk and share."

Nina willingly and eagerly shared her personal feelings of disappointment about this last minute change. Sudden short notice decisions, from higher levels, to cancel classes are possible in this context. I have experienced this in the past and, this was the first time since the start of the project that I had experienced it. This is a reality for the teachers and it alerted me to be patient, exercise flexibility, and be open to alternatives, such as talking individually with the participant instead of observing the lesson. The change in plan opened up space for me to get to know more about Nina's ideas about teaching and learning of biology. She is a seasoned teacher when it comes to teaching biology. However, when I questioned her "suppose you are given to teach chemistry or physics, how would you feel about it. Would you be able to teach it the same way as biology?" Her response was:

> To some extent chemistry … a few chapters where biology and chemistry are related. Physics it is very difficult for me to teach. I don't know it and I can't opt for it. Right from the beginning I have been weak in this subject and I never got a proper coaching in it and my interest was never in it. I had learnt so many words but I could never relate to them until I saw you (R) during the Subject Specialist Teachers Program. … giving those related and variety of practical examples in physics for reflection of light and virtual image formation ... and then we discussed image formation ... I still remember it, though it was done only once. Another example when you gave demo for the movement of the gas particles … that ammonia gas and hydrochloric acid in a glass tube moving from one direction to another and making a white cloud. So may be if I had learnt it in that way then I would have been interested in physics. I don't have the concepts and understanding of physics … how could I say I can teach … some teachers they still do it. You ask them anything they think they know it and can teach it ... but I wouldn't do it until and unless my concept is clear. In biology also there are so many things that I don't know but I've learnt and I keep learning. For example when my students gave their project work, I was surprised myself to look at the pictures and all the things that they had brought related to living things. Such a good project work on living things and new ideas ... I had never thought about these things (field notes/conversation transcript).

Nina's practical knowledge allowed her to articulate a theory 'if I don't have the understanding, how could I say I can teach' which is very consistent with the literature on teaching and learning. Furthermore, for her, a personal understanding of the concepts and presenting them in an understandable manner is an essential part of her practice. I found this very intriguing because it concurs with Shulman's notion of pedagogical content knowledge. Nina had yet another surprise for me: (Key: Nina for Nina and R for researcher)

Nina: This morning Father (principal of the section) asked me about you. He is impressed with you. The way you talked to him the other day (meaning during

my project negotiation meeting) and he asked if you could come and talk to other teachers in school to give some ideas about good teaching.

R: Interesting he has never met me before this meeting and nor did we talk much about teaching as such … How would he know I if … (before I could finish).

Nina: He liked the way you talked and then I also tell him and the other teachers … they know … I tell them (with pride) what I do … how I get ideas. I told Father you are busy … but may be some day you can come and talk just little bit … to boost the other teachers too.

R: Let us think about it during the course of this project and if it works out then we can try to do it together. How does it sound to you?

Nina: It is fine. (field notes/conversation transcript)

I thought I was being confidential about my research. However, the dialogue about Father's message triggered this thought in my mind 'How discreetly research can be done is questionable. The effects make it visible especially when the effect is positive and the participant has no objections … it can be contagious. There are signs of collaboration that I am already sensing especially from the school head. This strengthened my belief that heads play a significant role in expanding the working relationships with other teachers to affect their practice and learn from them.'

GROUP SESSION SHARING AND LEARNINGS

Our second group session was held on September 29, 2000 from 15:30 to 17:30. I had envisaged the group sessions to serve as an avenue for sharing ideas and information as well as discussing experiences, readings, resources, raising questions, and collectively learning from each other. Group sessions were, thus, to help build a 'community of learners' that would support and enhance learning in a non-threatening, encouraging, and respectful environment. I saw myself playing multiple roles. With the passage of time, I hoped to see a shift of roles to the other group members. I shared this expectation of mine with the group at the start of the session, "today I have drawn up the agenda for our session ... I hope in the future, with time, you will also contribute and together we can decide the agenda for the upcoming sessions." For my teaching and facilitating roles I next shared what I had identified as relevant items based on my experiences since our first group session and what I had planned to talk about with the group. I encouraged the group members to give their input to support the ideas with their own experiences at

appropriate moments as and when they felt comfortable. The agenda items were as follows:

a) Some characteristics of action research: inquiring process to bring about change with particular focus on the action research cycle; treats participants equitably; participants willingly choose to be in the group; values involvement of all participants; strives for shared lived experiences to benefit all participants; seeks to promote the professional practice upon; and collaborative endeavor and active participation.

b) Share summary of key points from session one especially the one on focus questions (copies of the summary were to be given to each member with emphasis on: confidentiality and how to maintain it e.g. using pseudonyms, keeping documents in safe place and preferably locked; accuracy of ideas and translations from Urdu to English ... checking it by sharing text and documents). This was also to serve as member checks of my data.

c) Discuss any matters arising from summary in b).

d) Conclude with the two cycles (visual representations) namely 'PCK-Teaching Process Cycle' of Wilson, Shulman and Richert (1987) and 'The Action Research Cycle' (see Appendix 4) and their connection through the notion of reflecting on actions.

For the discourse of the group sessions, I followed a predominantly constructivist belief of first eliciting the participants' ideas on the focus areas or questions and then building upon that for a more in-depth understanding. This was to allow the participants to take a lead role and ownership rather than the researcher. For the day's session, I initiated the dialogue by asking the participants to respond to PT's request, 'I want to know more about Action Research.' (Group Session One, PT September, 15, 2000)

Understanding: Action Research

Saira and Nina gave informed definitions of action research with practical examples from their own experiences. Simultaneously they shared and identified their concerns:

Saira: I think we are reflecting ourselves ... on some issues or problems which we are facing during delivery of lesson to find out these focus targets and then think about what we can do about these areas. Action research, I ... consists of three phases like we plan, action, observe, reflect and after reflecting we again re-plan in the area we need to work on. This is my thinking (laughs ... and looks as if surprised and yet pleased with her response). After classroom visit day before

yesterday ... we (Saira and R) met. I discussed with her (R) some of my concerns which I face during my lessons. The main thing is time constraint, which we are always facing. I wanted to achieve three objectives ... I couldn't within the time. Second thing was an issue that we face ... students' interest in reading. Something that I wanted to deliver in my lesson perfectly, it did not go as I planned. I then sorted out some of my concerns and now I want to work on it.

Nina: Content knowledge is my concern and its planning and teaching ... it (action research) is inquiry process to make a change.

Saira: In science lessons, inquiry is already included ... I don't know the definition of inquiry but whenever we start science teaching, we start from ... like prediction ... what is going to happen next or what is happening. Isn't this an inquiry? (Questioning ... while looking at me).

R: For me inquiry means asking questions, not taking things for granted but questioning ... even if I think my lesson went well I need to still think about it ... what went well, why? Is there something that did not go so well? How can I make it even better ... it is to look for improvement through inquiry into ... own practice, ask questions, make some time for it, time is of course a big question (we all smiled and looked at each other) and then of course it is to follow the process systematically ... in cycles ... (conversation transcript/field notes)

After this basic understanding of action research, we went deeper into it by considering the 'characteristics of action research,' in particular 'participants willingly choose to be in the group' and 'treats participants equitably.' I believed that these two characteristics were good to start with which to further clarify the nature of action research. That is 'volunteer commitment' and 'respect for others.' These also provided a natural flow into our talk about the remaining characteristics, namely involvement, active participation, and promoting professional practice. Considering the diversity amongst us, the word 'equitable' was questioned; 'How can we be equal' (Group participant's comment September 29, 2000). I proposed my interpretation of it as "respecting each other, listening to each others ideas and views, and ensuring that every one gets a fair chance to 'voice herself'." Though this seemed agreeable to the members, I noticed it not being practiced. Initially most of the talking was done by Saira and Nina. At a strategic moment I intervened, "I think we need to remind ourselves about (emphasizing) 'equitably'." Nina quickly picked up on this, "I see ... because PT is not saying anything" and she invited PT to share her views. PT responded positively and became more involved in the talk (field observations/notes). Our subsequent conversation brought to the surface individual or group perceptions and feelings about a number of pertinent teacher knowledge and development aspects: personal growth or development,

practical work at the primary level, and teaching for conceptual understanding. These will be shared next. We concluded the session by recapitulating the main ideas and making their connections to the action research cycle and the teaching process cycle of Wilson, Shulman and Richert (1987).

Professional Growth

During the course of our talk on action research which 'seeks to promote the professional practice,' an interesting discussion on whether or not 'growth is continuous' took place. There seemed to be a difference of opinion amongst the participants as they challenged each other:

Saira: It (growth or development) is an on going process...
Nina: There are so many things to overcome I think, throughout life and teaching that it ... improvement goes on ... I think a person is never perfect. He keeps on finding new things and growing (Saira in the background in soft voice emphasizing ... goes on ... yes yes).
PT: If you are satisfied with your practice, I think you can ... but it does not mean that you have stopped. You taught one lesson you are satisfied but may be next lesson you are not.
Saira: What do you mean when you say satisfied?
PT: For example, I have one concept, I have given them and actually as I had planned to teach and it went as I had planned, as I wanted it to go ... activities took place the same way, so I feel happy ... if there were some problems ... I would say yes there are some ... (group session transcript)

For the next little while, Nina and Saira argued about PT's claim "if it (lesson) went as I had planned, as I wanted it to go ... you are satisfied with your practice ... I think you can say development or growth come to end." They believed that no matter how well a lesson is planned, when it is enacted, it may not always go as planned. There is always need to seek improvement either individually or together with others:

Saira: Planning we may do as best as we could in good way. When we take it (lesson plan) in actual situation, may be we can face some differences there. Because actual situation is according to students' knowledge ... they (students) have and whatever we want to give extra or according to our syllabus/textbook knowledge ... may be students can take in different way or may be our planning is problem. It is my opinion. I am not saying that it happens with everyone and all lessons. There is always chance of little bit lacking or something being left out.

Nina: You always need ... somewhere or the other, you need improvement. Something is always missing. Every time that I teach a topic, it is never the same for classes that come after. When I am teaching a topic, supposing to present class eight and the same topic I am going to teach to the coming class eight , it will be (stresses) different. It never is the same because students keep on changing and I keep on changing the lessons, even when I find myself that this time I have done this ... it has gone well but I say supposing if I don't do it like this and I change it in another way ... so this way lesson keeps on improving and I learn.

Saira: Sometimes we cannot do it individually ... it is my opinion.

Nina: You start getting better ideas ... together. Don't keep just one fixed plan. If we planned one lesson one time, it does not mean that forever we are to go with the same lesson. (group session transcript)

The participants not only raised an important question 'even though one thinks one has made a good lesson plan, how does it work in an actual classroom situation?', but also a need for a flexible plan in accordance with the students' needs. Collectively we listed some factors that can influence a lesson plan: teaching a lesson on a different day; at a different time of the day; to a different group of students; or on a different topic or a new topic. In fact, sometimes even with the same group of students it may not work exactly as planned. Nina then gave her rationale about feeling satisfied or not satisfied about the lesson 'it depends on what they (students) have learnt.' This helped me to pose further questions to the group 'how do we find out whether or not we are satisfied with the lesson plan?' More importantly, how do we know that the students have learnt the science content? As a group we came up with more inquiry questions: What did I want the children to learn? Have they learnt? Why? Why not? How do I know? What can I do to improve the situation?

Practical Work at the Primary Level

The theme of this section emerged out of PT's claim "I mostly use demonstrations with primary classes." Her reasons for this claim were: safety in case of chemicals or flames and difficulty in providing enough materials for a class of 43-45 students. She gave an example of teaching a lesson on the change of state: "To boil water, primary level students are very young to light the stove and it is difficult to bring 43-45 ice cubes for a large class." I invited the group to respond to this. The overall thinking of the

group was that the students 'enjoy doing things most' and 'kids who take interest even go home and try things out.' PT acknowledged this as well, "children enjoy most and like doing ... like I have this girl whose parents in the parent-teacher meeting told me that when their girl gets home, she pretends to be Miss PT and performs different experiments (burst out laughing)." Saira saw practical work as a foundation for the secondary level: "Our students ... who do practical when they advance to class six give very good responses in the science labs." Nina suggested alternatives for PT's ice cube problem: "Ice blocks and ice balls most children play with in our hot country ... children also buy ice in small plastic bags from the vendors on the streets to eat ... children can talk about these or PT can bring some ice blocks and break it to make more pieces." The group believed in having practical work at primary level not only for fun, but for learning science as well as developing practical skills for future. This raised the question for us, 'how do you know that students have learnt the intended science concept(s) from the practical experiences?'

Conceptual Understanding

Teaching the abstract concept 'mass' was problematic for PT. To discuss the above question I requested the members to use 'mass' as an example. I saw this as an opportunity for group members to clarify their own knowledge about it. In addition, it seemed to be a way to illuminate possible problems inherent in teaching such a concept and to think aloud some representations which could make it more comprehensible for students. Nina initiated the discussion, "students find it difficult to differentiate between mass and weight. If a learner can explain the difference then it is understood." PT then brought to attention a cultural problem, "in Urdu there is only one word '*wazaan*' for mass and weight. In fact '*wazaan*' is also used as a verb meaning to weigh." PT's idea to check for understanding was, "if child can explain the concept in his own words then the concept is clear to the child." My further probing revealed that though PT knew the book definition of 'mass' she still had a problem with recognizing that the representation she had used was inappropriate:

R: What do you think they (students) will tell you...?
PT: (Hesitantly) The child can say ... stuff, quantity ... amount of matter inside.

R: From your experience of teaching mass at class two level ... what have you found children saying?

PT: When, I have given them wrappers and I've asked them to sort out what is found in it … why have you written this in liters and why that in grams? There were peanuts ... asked why didn't you write that here (meaning liters)? So the children responded that because it is solid and ... grams is written on the packet. So we wrote it by reading on that packet. I said okay gram was written but why didn't you write it in liters? ... they said ... because it's solid. That's why I ... grams and not in liters. And water ... in a bottle ... they said because it's a liquid that's why I wrote it here (meaning liters column).

R: So ... you are saying the child has understood the concept of 'mass'?

PT: Little bit, yes.

R: Perhaps.

PT: Yes, may be children have … but they did write in solid or liquid. (group session transcript)

PT switched back to the idea of 'mass,' as, 'if solid is measured in kilograms or grams and if liquid in litres or milliliters.' She was unclear about whether she was talking about the concept 'mass' or its measurement. Furthermore, she was also unclear about the units of measurement of mass. For PT to transform textbook definitions of the concepts in a comprehensible way using effective representations was problematic. In the process she tended to slip into a mode of 'telling.' This was also evident in a later segment of our talk (field observations/notes):

PT: This lesson (meaning on 'mass') was fourth lesson on matter ... we had done definition of matter that ... 'it has mass and occupies space' …

R: Here you have two concepts 'mass' and 'space.' Do they have the same meaning?

PT: When I taught matter to the students in lesson one we brought a boiled egg and by removing the egg shell, we said that this edible part is called 'mass.' Just take the example of an apple, what is the fleshy part that we eat? When we asked the kids about the apple, they would say we eat the fleshy part. If asked about the egg, they said we eat the white and the egg yolk. They would not say mass. So the teacher then tells the actual word. They have the concept … then we told them the right word that it is called the mass. (group session transcript)

During the course of our group sessions at times I found it difficult to make decisions such as: How long should I let the talk take its course; when should I intervene; when should I give explanations; and when should I leave it for the group or the individuals to take charge of the discussions. Often I had to use my intuition and tactfulness to make these kinds of decisions. For example in the above dialogue it was just PT and I talking

while Saira and Nina were quiet. Furthermore, PT was still confused about the concept of mass and its unit. I felt it appropriate to end our talk at this point. This also allowed me to bring a more focused closure to the session without taking more time from the members or rushing them. The group members appreciated this as is reflected by these comments, "it is very difficult to make the students understand these concepts especially at the lower levels ... this happens even with educated adults ... we have to clear our concepts first."... "Yes, yes it needs time."

With the help of the visuals 'The Action Research Cycle' and the 'PCK - Teaching Process Cycle' (see Appendix 4), I recapitulated the main features of action research and pedagogical content knowledge with reference to the key stages of each cycle. This also helped me to impress upon the teachers the common feature of the two cycles: reflecting on the actions, revising the plans, and making cycles at higher levels of thinking and comprehension. The most challenging stage of the cycles in my opinion and experiences is the 'evaluating and *reflecting*' one. We brainstormed alternatives to engage in reflection. Our alternatives were: audio and/or video recording and playing back the tape; inviting a trusted colleague to make observations on a focus area and provide feedback; making deliberate time and effort to self reflect; or combination of the four alternatives like self-reflection followed by input from colleagues. The participants liked the last alternative as Nina's words suggest:

> That's a better way ... because you don't realize when you are teaching whatever are the errors in that or whatever mistakes you make in that until and unless you do own evaluation. With own evaluation you can find a few. But whatever you've been thinking throughout your lesson, you can't catch all your mistakes until and unless you've a proper guide towards how you are going to review. Reviewing can be done only when you have some record on that or some help. (group session transcript)

Both Nina and Saira liked the idea of videotaping a lesson. They opted to ask for school permission themselves and then to inform me so as to plan and organize this. It was encouraging to end the session with the members taking personal responsibility. Furthermore, even though the session ended, the participants were still engaging in informal sharing amongst themselves about how a videotaped lesson could be used. Some of their ideas were ... 'whatever students are doing we can easily reflect ... all the students ... what the students are doing at that moment' ... 'you can share it with other

teachers, they can learn from it and if you don't mind, they can give points which you haven't been able to self-reflect upon' ... 'if other teachers want to improve their professional growth ... they can learn to reflect.' Though this was an end to a fractional part of the whole project process, it was an inspiring and enlightening new, yet uncertain, beginning to our next part working together.

A WAY FORWARD

Many intriguing and intertwined notions related to teacher education, including pedagogical content knowledge and curriculum, surfaced during this exploratory period. There were surprises much like the change in practice PT once had about three years ago after an intensive one year field-based teacher development program when she happened to slip back into a transmission mode of teaching. When I compared this teacher's verbal perceptions about her practice with her actual teaching style I detected some inconsistencies. It seems it does not necessarily follow that what one says one practices. Woods (1996) has captured this well:

> Beliefs and their interrelationships may not always be entirely consciously accessible, and teachers may, in responding to questions about generalized beliefs, answer according to what they would like to believe, would like to show they believe in the interview context. When a belief or assumption is articulated in the abstract or a response to an abstract question there is a much greater chance that it will tend more towards what is expected in the interview than what is actually held in the teaching situation and actually influences teaching practice. (p. 27)

Nonetheless, the teachers' classroom actions had indications of the influence of their beliefs, thinking, and experiences. Sharp and Green (cited in Gott and Duggan, 1995) have observed, "the significance of teachers' beliefs...to the roles that they adopt and... (their) influence (on) their practice" (p. 62). One of the partners who believed that primary children are too young to handle materials safely and that resources are limited adopted a demonstration approach. However, the other partner believed in laying the foundation for practical work at the secondary level and that, by providing and practicing appropriate safety measures and social skills, upper primary children can do hands-on work. Hence, this teacher adopted cooperative group work for practical activities.

The more time I spent listening to and observing the teachers' practice as well as reading relevant literature, the more I conceptualized the notion of teacher development.

I have come to believe that it requires among other things, a broader understanding. Though my study is on the pedagogical content knowledge of teachers, I could not see myself staying away from interchangeably and unconsciously using terms like professional development, teacher learning, and teacher growth. This is in accordance with the representation by McNergney & Carrier (1981) of teacher development under various terms, such as teacher education, professional growth or development, professional learning, and training. This made me aware of the conceptual overlap, complexity, and fluidity within teacher development itself. Ultimately all these notions, according to Burden (1990), co-mingle to identify the unique and common needs and abilities of the teachers as well as offer support and development opportunities for their short and long-term growth. This is equally valid for teachers' growth in pedagogical content knowledge.

Reflecting on the diversity that I had noticed in exploratory experiences within the three partners I became increasingly aware of the unpredictable, uncontrollable, and paradoxical nature of teacher development. Thiessen & Kilcher's (1991) thinking in this respect is that not only do different teachers grow differently, but even the same teacher develops differently within different times, places, and conditions. This is very apparent in the three cases I explored. However, teacher development is no doubt a continuous process, a life-long learning process. It needs time and mental space, it requires time, effort, and an attitude of willingness and commitment to engage in appropriate experiences, especially on the part of a learner. Burke (1987) has stipulated many avenues for continuous improvement, "expansion, advancement, maturation, elaboration, conversion, evolvement, and progression (p. xi). Engaging in these processes teachers are expected to become better pedagogues to "fulfil their own unique needs and what others expect of them to do" (McNergney & Carrier, 1981, p. 1).

No matter what process or avenue and under which teacher education term one considers, to me it is the teacher's experience that is the 'teacher.' I do not mean experience for the sake of experience, but an experience that can make a teacher grow. Johnston (1994) puts it eloquently: "Experience alone is not enough. It is the thought and subsequent action associated with the experience which determines value in the learning process" (p. 207). That is to say that teachers are actively involved and they use

the experience to learn about teaching. This active process is worded by different scholars in different ways. Russell (1991: cited in Johnston, 1994) constructs his thought from Schon's reflection-in-action concept and stresses that practical knowledge stems from experience if and only if one has "a perspective that recognizes the possibility and the importance of being attentive to experience and the opportunities to learn from it (p. 2). For Rubin (1989) intuitive knowledge of good teaching often occurs "from insight gleaned through past classroom encounters which repeatedly have been processed and internalized through reflection about teaching and learning" (p. 32). These are not just circumstantial, but lived experiences. According to Britzman (1991) lived experience is "our capacity to bestow experience with meanings, be reflective, and take action. Without an awareness of potential and given meanings, and our own capacity to extend experience through interpretation and risk, without this active side, our capacity to participate in the shaping of experience is limited" (p. 34). I concur with the descriptions of these scholars as it is this active process which, to me, is central to the Action Research and the Pedagogical Content Knowledge cycles. It is with these new insights and guiding principles that I moved into the next collaborative phase of my project. My insights of this phase are captured in my journal entry:

> I am overwhelmed by the struggles of my group members in their efforts to blend content and pedagogy for their pedagogical content knowledge ...This is a tall order for these members especially when they themselves have not been brought up with such an approach and yet they are grappling with it in an effort to make a difference for their students. It makes me question where to start and how big a bite I can take or for that matter group members can take. The best way is to start small with what is manageable within the resources of time and energy and school expectations in terms of what content to teach, syllabus to cover. But as a project facilitator encourage, guide, and support the members to achieve their identified concerns. (personal reflection, September 29, 2000)

Chapter 5
COLLABORATIVE ACTIONS

This chapter is about our collaborative efforts to systematically work towards helping the participants to achieve their identified concerns in the exploratory stage. The chapter begins with some pertinent general considerations to set the tone. It then discusses each individual participant's case. It ends with our collective sharing and learnings for this collaborative period.

INITIAL ACHIEVEMENTS AND SURPRISES

October 2000 saw an encouraging as well as a surprising start of the project. Nina (in an excited and pleased voice) said, "Charan (R), my principal agrees to video record my lesson" (phone conversation October 2, 2000). Saira had also received permission from her administration (journal notes):

> Madam (her School Head) said, "I (madam) have no objection to make video of your lesson. It will be good to have it at our school to use for other teachers too. This videoing is a new thing we are doing so it is important we get permission from the campus principal also." (phone conversation October 3, 2000)

When I asked Saira how she felt about using a video for her colleagues, she responded, "I would like it too because it will help me and my colleagues to get help. It is for reflection and learning." A day later Saira called, "My campus principal says 'yes go ahead do it.' We can video next lesson" (October 4, 2000). This was an encouraging indication of the head's collaboration. I was excited and impressed by the efficient communication of both Nina and Saira with their administration and by the success of their negotiations. However, I was surprised and disturbed by PT's journal entry: "No doubt this program (project) is very useful for me but due to my family (personal problems) I cannot continue with it" (Journal Entry October 5, 2000). I was bothered by this because, in the past, especially during the Subject Specialist Teachers Program, I had witnessed PT's talent in making and using teaching aids such as paper mache three dimensional models of the moon's phases to complement a two dimensional poster. She had demonstrated a capability of managing small group work in a class of about forty students. I felt a need to dialogue with her (journal notes): (Key: R for researcher; PT for the member)

R: I do agree that time is a constraint and it does influence other personal activities.
PT: Yes, my mother is not well and I also have to help my daughter who is to sit for Board Examinations (National Matric Examinations locally administered). This made me to say I want to drop.
R: Do you still feel you want to drop?
PT: I am not sure.
R: What would you like to do?
PT: (after a pause) Let us try I would like to continue and contribute whatever I can ... there is only one thing that at home also I have responsibility ... mother is not well ... I want to teach her (daughter) with activities but Board Exam cannot accept this. So I have to help her to rote learn every thing. (field transcript)

Personal life and family commitments can interfere and influence decisions which teachers make. I suspect making space for PT to talk helped her to change her mind and agree to continue. This helped me, as well, to have a better understanding about the member. I have a firm belief that teachers have a moral obligation and responsibility to their students. At the same time, I feel their personal lives cannot be ignored. I needed to take this into account and be sensitive to it during the process of working together for a change.

Formal Teaching Time Available

> How much effective, formal, undisturbed time is available for teachers to complete the task of completing the syllabus and enriching the curriculum? (Personal reflection October 31, 2000)

The above question arose from: my observations during the exploration period; the information the group members shared with me on an on-going basis; and my previous experiences of working with teachers in Karachi, Pakistan for the last decade. During the exploration classroom visits I witnessed that the school bell times fluctuated. Furthermore, there was no time budgeted for the students to move from one classroom to another classroom after every lesson. The students, especially the primary ones, with their heavy and bulky school bags, needed time to settle down before the start of the lesson. At times, there were also last minute cancellation of classes. With the passage of time, more pieces of information came from the members about instructional time:

> Our main office (AKES-System's) has just decided to close down the school for the week October 23, 2000 to October 28, 2000 to accommodate the community's spiritual leader's visit and the related community services. (Message from PT and Saira October 16, 2000)

> First week of November my classes are cancelled. On Tuesday I have decided to attend a workshop 'Marking Scheme of Cambridge Exams.' I do not like to leave my students. But I am teaching Cambridge Class for the first time and I decided myself to go for workshop because I do not know it (marking scheme) ... There is no other teacher to take my class. On Friday our school is having a *Mela* (a cultural event) ... teaching is cancelled. Most extra-curricular activities and festivities happen to take place on Fridays. My lessons (in a disappointed voice) get cancelled. (Phone call Nina October 30, 2000)

> Charan our class Vs' lessons will be used for Australian Achievement Tests. First week of November there will be no teaching for class Vs. (Phone call Saira October 31, 2000) ... 13th to 24th December ... have to do revision for the mid term exams ... so we have to complete term syllabus before mid December (Group session Four, Members, November 10, 2000)

When I asked the members 'how do you make up for these lost lessons?' Nina said, "During regular school weekdays it is difficult … I try to add lessons at the end of the year … but that is not always easy" (Group Session Four November 10, 2000). PT and Saira said they either use other teachers' lesson time or they just do the best they can (group session notes).

When a directive comes from the top to cancel classes or to close the school, teachers are powerless. When teachers are away, students may either miss classes or other teachers are required to teach extra lessons. Besides the above mentioned reasons or events for loss of formal instructional time, many others were brought to my attention. For example, local and national strikes which I have often experienced over the last decade that I have worked with teachers in Karachi, as well as shorter working days during the month of *Ramadhan*. *Ramadhan* in the year 2000 started on November 28, 2000 and continued right through the month of December which was then followed by Eid and New Year holidays. This had implications for my project group members. To accommodate prayer and preparation time for Ifftar (the daily fast breaking event during *Ramadhan*) and the dinner, Saira suggested changing the timings for the group sessions and also to keep them short. As a group, this was acceptable for everyone's benefit. However, Saira, who liked to be punctual and present in the group sessions, had a disappointing experience on December 1, 2000, our fifth group session day and the first Friday of *Ramadhan*: (Key: R is for researcher; Saira and Nina the group members)

Saira: (arrived one hour late) I am very late … (in a very apologetic and disappointing voice).

PT and Nina: (empathetically) today being the first Friday of the Month of Ramadan … it is difficult.

Saira: Yes ... there was traffic jam … transport became a problem.
R: ... We did miss your presence. We waited for about fifteen minutes and then as a group we decided to carry on ... talk is audio recorded for you to listen to what you missed ... I will have a copy made and sent to you.
Saira: It is alright ... I would not have liked others to wait … they have other things to do and discuss … I will listen to the audio tape and know … I do not like to miss group sessions … but … (still feeling unhappy). (group session transcript)

The realities of this context are the result of many factors, some external and some internal to the school, which put pressure on the teachers. This information was valuable for me. It impacted the project and gave me a better perspective on the demands teachers have. In this situation, what standpoint was I to take? My journal entry which I shared with my group members reflects my feelings:

> To exercise flexibility and be attentive to sudden changes with positive attitude and open mind is the best way to move the project forward rather than feeling frustrated and working with negative energy that can become a constraint. (Personal reflection October 31, 2000)

Bearing in mind the above genuine concerns of the teachers and taking into consideration my teaching assignments scheduled for the period January 2001 to May 2001 at my institute, flexibility was desirable. I also needed to be attentive to use the time available to us effectively without attempting to change the instructional programs and routines of the schools. Being flexible and attentive was also necessary because of the diverse nature of my project group members. I perceived this to be both a challenge and a way to bring richness to the project. I asked myself, "How best can the project now be approached to move it forward?" During the exploration period a way of working that had set the tone had developed. It seemed logical to continue with this since it was also agreeable and familiar to the rest of the group members.

Content, Approach and Concerns

The participants taught varied topics with common strands like living things, matter, and energy. Their approaches depended upon the level taught and their personal beliefs about teaching and learning. PT used in school pre-prepared lesson plans that reflected a fragmented topic-wise planning and teaching style. Saira followed a thematic approach as outlined in the school-prescribed text book chapters. She explained her intent to cover

a chapter in each one hour lesson: "I want to complete all the chapters of second term for exams in the time period I have" (Journal entry Saira September 27, 2000). Nina, who taught the overseas 'Cambridge O-Levels' biology course, had a very discipline-oriented curriculum.

The participants' mode of discourse varied as well. PT followed a predominantly transmission mode. Saira attempted to experiment and try out new ideas and strategies to make science interesting and encourage more student participation. Like Saira, Nina was also trying out and experimenting with innovative ideas to shift more responsibility for learning to the students. Simultaneously, she was acclimatizing herself to the new syllabus and its expectations to prepare the students for an external examination. Nina was also grappling with building relationships with the new administration, the physical facilities, the resources, and the resource persons or lab assistants.

It was not surprising that the areas needing attention for each group member differed. PT's concern was how to engage students in learning and to manage this in a large class of primary two students. Saira was concerned about maintaining student interest in reading and having active student participation in the lesson without rushing it. Nina wanted to enhance her own conceptual understanding of biological concepts and to link concepts from other disciplines like chemistry, physics, and mathematics:

> While teaching biology, when it comes to any math concepts/ ideas e.g. graphs, ratios like surface area is to volume/anything to do with calculations I find it difficult to teach because my own concepts are not clear and I don't understand them ... In order to teach Cambridge students biology, I see that there are graphs to be drawn and explained. For example how absorption is related to the ratio of 'surface area: to volume' of different sizes blocks ... I have no one ... to help but I collect books ... read and try out exercises and keep on reading again and again until I feel I am getting a better understanding ... I read through the text and tried to understand the math behind and the given explanation for the question 'why are cells small in size?'.... After doing the activities myself I had better understanding and I felt more comfortable to give this activity to the students as a help to understand the 'why' of the question. (Informal conversation November 4, 2000)

Each partner in the project was special and needed to be approached individually. Thus the nature and extent of my way of working with each of them varied. At the same time, I had to attempt as much as possible to have the partners make and take decisions affecting their teaching. A quote cited in Parkay (1996, p. 50) further clarified for me what this was to entail:

> Teaching ultimately requires judgment, improvisation, and conversation about means and ends. Human qualities, expert knowledge and skill, and professional commitment together compose excellence in this craft. (-National Board for Professional Teaching Standards (United States))

GROUP SESSION SHARING AND LEARNINGS

When I presented my data documents to the group at our fourth group session on November 10, 2000, I was surprised by my partners' observations, remarks, and questions (group session observations): (Key: R for researcher; Nina, Saira, and PT for group members)

Nina: I have also started writing like Charan (R) … all the details … it helps me
Saira: It is amazing you have noted and organized each and everything. What is the purpose for this? If I have to do research is it what I have to do?
PT: (gently placing her hand on Nina's shoulder and facing her … with a smile) we will have another Miss Charan (R) (laughter in the group).
R: I am amazed at your keen observations. Gathering and organizing data is part of the process of research. I am trying to organize it so as to make it easier for ... writing about my project. I also need to share it with you ... to correct and clarify information for increased accuracy. This is important for my research and research in general. (group session transcript)

Saira raised a question 'if I have to do research is it what I will have to do?' To me, Saira's question suggested her unawareness of already being involved in research. I felt a need to clarify this for the group (group session observation):

R: Saira has ... an interesting question. Any comments …
Nina: We ... are doing little research!
R: Just little!!!!
Nina: No, like the other day my boys (students) were doing practical work in biology for the first time … my students faced difficulty in handling, knowing names of and using apparatus … even I found I needed to clarify my concepts … I thought concentrated solution makes the level of liquid in the thistle funnel to rise when you just immerse it in a beaker of concentrated solution in an osmosis experiment … after Charan's discussion ... I discussed it with an A-level chemistry teacher at my school I learnt it is the pressure difference … I have learnt when in trouble or doubt better seek help rather than teach without understanding that could lead to misconceptions in children. I re-planned my lesson and taught it again … students gave better responses. (group session transcript)

Nina's practical example helped PT and Saira to realize that they were researching into their practice as well. They provided anecdotes to this effect:

PT: Like after viewing video and then co-teaching with Charan (R) lesson on 'floating and sinking' … doing 'surprise activities'… telling stories to have girls' attention and have them talk … telling stories … children listened attentively and it helped to settle them.

Saira: Like in the beginning I was talking more … now my talking less helps me to listen more to my students … (stops).

R: Indeed and most of this you have written rather recorded in your journals or spoken into the recorder … so you have all contributed and …

Saira: (with smile on her face) doing research … (group session transcript)

This was encouraging. In the talk the participants had articulated changes in their pedagogical content knowledge that have occurred since the beginning of the project. Nina recognized the need to attend more to her content knowledge, whereas PT and Saira realized the importance of engaging students in interesting tasks and listening to their talks. However, Nina's phrase 'like Charan' and PT's phrase 'we will have another Charan' made me cautious. My intent was not to have them think, act, or be like me; I wanted them to think about what they were doing in accordance with the guidelines of Heider (1985, cited in Stephenson, 1994, p. 46):

> Remember that you are facilitating another person's process. It is not your process. Do not intrude. Do not control. Do not force your own needs and insights into the foreground. If you don't trust a person's process, that person will not trust you.

To facilitate the process, I consciously worked hard to balance telling with suggesting and requesting. I asked my participants to try out, experiment, and reflect. The participants were aware of this and were willing to do this as these comments suggest, "we need more time for feedback ... reflection" (Saira) ... "I feel happy when we share and discuss ... you ask questions and make suggestions ... it helps a lot to do more and learn more ... but (in a disappointing voice) teaching is being interrupted and that too during project time" (Nina). To address the above mentioned concerns of the participants I prompted them to engage in organizing their learning into a grid with columns: date; lesson topic; brief lesson description; method; comments; and lessons learnt (for samples see appendices 5a, b, and c). I believed this exercise would: encourage the participants to revisit their journals or any other relevant sources and reflect further upon this data; help them to follow their own individual growth; serve as an organized data collection tool to monitor the changes in their pedagogical content knowledge, such as science content knowledge and classroom management; help to maintain project continuity

during teaching interruptions; and provide an opportunity for the participants to improve their English writing skills.

The positive changes in their pedagogical content knowledge (see pp. 98-99 above) described by the participants were the outcomes of our collaborative efforts. These efforts will be shared next as three case studies.

CASE ONE: PT

Prior Experiences and Initiatives

A challenge for me came when PT hypothesized 'the problem of large classroom strength of students ... nobody can solve ... so it is better to compromise with it' (PT's journal entry September 21, 2000). Her talks and practice during the exploratory stage reflected her thoughts of students as passive listeners who write down teacher given factual notes at the end of the lesson which they have to memorize for exams and which provide satisfaction to parents that their child has learnt. To test PT's hypothesis, I offered to co-teach with her. PT, with her school head's permission, accepted the offer. As a teacher educator, I had taught and observed teachers at this level on several occasions, but I had never formally taught children. I had mixed feelings of excitement and uncertainty as to how it would evolve. It was an excellent opportunity for me to gain first hand experiences and insights into teaching at this level. I felt that I would become a better teacher educator for future student teachers. Nonetheless, I worried about being a threat to PT's authority. My journal entry speaks for this:

> I would like to work together with PT ... with PT taking more initiative and ownership while I play the critical role to facilitate, support in encouraging environment,. I am more than willing to co-teach without threat to PT's authority. Though this will be the real challenge. I will have to deal with this and make conscious effort to work at it as a co-teacher and have PT to be in the lead role as much as possible unless otherwise desired by her. (Personal reflection September 30, 2000)

Co-Planning and Co-Teaching

To highlight the nature of our interactions and my multiple roles, I have selected the last of the three co-taught lessons on the concept of 'floating and sinking.' One complete cycle: planning, acting, and reflecting will be followed. Only selected and relevant

dialogue segments, descriptions, anecdotes, and other forms of resource will be used.

(Key: R for researcher and PT for the group member)

Planning

PT: (in a relaxed voice) I have made a plan and I am thinking why don't you (R) take first twenty to thirty minutes of the lesson and do the motivation and the demonstrations that we didn't finish ... Then I will take over and finish up with the 'copy work.'

R: ... what about the discrepant event demonstration you had wanted to do and completing the activity from last lesson on testing the items as floaters or sinkers using the Predict Observe and Explain (POE) strategy?

PT: Yes, it is there after demo.

R: How about we do demonstrations together ... your discrepant event and mine 'Naughty Egg' surprise and fun activity with student involvement.

PT: Yes, I will do the rest.... and complete 'copy work' with girls.

R: When do we meet next?

PT: On Tuesday ... for lesson.

R: Could we possibly meet before lesson on Tuesday ... like on Monday to familiarize with the room and have resources tested and organized and do the final check of our plan ... make necessary changes? It would help.

PT: Now that we have talked on the phone we do not need to meet.

R: Where do I meet you on Tuesday?

PT: Which classroom we will have on Tuesday I will know on Monday. We are having all Class Vs to write exams and classrooms will be used ... we may have science lab or auditorium for our class.

R: Since these rooms I have not visited it would help me in fact I think both of us, if we could briefly meet on Monday to familiarize with whatever room we have to teach in and plan the organization of class and resources?

PT: Yes, we can.

R: Where do I meet you?

PT: I will wait for you in the staff room after class. (conversation October 29, 2000)

From our talk it is evident that PT and I differed in our approach to planning the lesson. For PT, writing up a plan was adequate. I had to impress upon PT the need to consider looking into the physical facilities and resources in terms of their appropriateness, availability, function, and organization. Then, if required, to make necessary changes to the plan. Twice before, PT's inadequate practical planning had lead to problems. The first time, it was for the exploratory lesson and the second time was during our second co-taught lesson. In both cases, the resources seemed to have been collected without much thought for their appropriateness. For example, the use of an opaque gas collection laboratory porcelain trough for the 'floater/sinker' demonstration

made it hard for the students to make observations. They got frustrated and impatient. This caused a commotion in the classroom and it took extra time to settle the students. The activity could not be completed and had to be carried on to the next lesson. PT's post lesson reflection supports this as well, "girls were not able to see ... became difficult and it (lesson) did not get completed." For the third lesson, PT prepared the plan and shared it with me. We arranged for an alternate container for the 'floater/sinker' activity.

We met on Monday, October 30, 2000 as we had agreed. Since we were assigned the science lab for our lesson, we spent about half an hour to set it up. The science lab, as I learnt, was primarily for classes four and five to do practicals, whereas classes one to three were normally expected to do all their science works in their respective classrooms. It had basic facilities like sinks with running water taps, a gas hot plate with a large metal kettle to boil water, and a waste disposal. The furniture included six circular tables, a circular metal top, and adjustable stools around each table. There were a number of stools which were wobbly or partly broken and unstable. While the tables and stools were more suited for older children rather than younger students, the class two students could manage to sit comfortably and use the tables. The furniture worried me in terms of its safety and its ease of use for the students. I shared this with PT and asked, "Are there any other stools or chairs we can have access to?" PT just looked and said nothing. I took this to mean 'no.' Upon my suggestion, we checked the stools and removed the most unsafe ones. We adjusted the stools which were reasonably safe to an appropriate height and placed them around the student tables in close proximity to the teacher's table to enable her to keep an eye on them. When the lesson began, we requested some students to stand and to not sit on the unsafe stools. Other than the porcelain troughs in the lab, there were no appropriate containers for the experiment and PT was not sure of any other option. She agreed to my offer of bringing my improvised containers made out of 2L and 3L clear, mineral water, plastic bottles. We planned and prepared the chalkboard and made some changes in the plan to allow for students to take notes which was a concern for PT. We left with these words:

R: How do you feel?
PT: (smiled) Good.
R: I feel good too. Thanks for making the time. (field observations and notes)

Acting: Significant Segments from Classroom

PT: (PT starts her POE activity) Okay when I am going to put feather in water … What will happen? Will it float? Or will it sink? (silence in class) Okay ... How many of you are saying sink? Raise your hands (no response) ... How many girls say it will sink? Put up hands ... in your this column (points to 'prediction section' of the table on chalk board) there are three columns; float, sink and not sure. How many girls say it will sink? (some hands go up) They put tick (✓) in sink … write feather and against it put tick (✓). How many children say float? (some hands go up) How many children say float? In first column you put tick (✓). (lesson transcript)

PT sought different ways to get student responses during the lesson. However, the students seemed confused ... miss where in first … miss where … miss where ... girls were seen looking at each other's worksheet as if seeking help ... R not very far from PT catches PT's eye ... PT pauses ... R softly, 'may be we go round to help?' ... PT 'okay' (field observation).

I (R) moved over to a table to help the girls make entries in appropriate columns by questioning and doing one example on one of the girls' sheet and walked to the next table to check and help … PT decided to follow R's strategy and together we covered five tables. PT got back and continued the lesson (field observation):

PT: Now this stone ... will it float or sink? (R discreetly moves around to help the girls in need ... PT also paused and moved to some tables to check progress ... and helps) (lesson transcript)

I was pleased to notice that PT decided to follow my strategy of moving to different tables and doing a quick check of student work as she proceeded ... even her conversations at the tables with the girls had taken a turn from what had been witnessed in the exploration period. They became more engaged and supportive of students' progress, as the following segment demonstrates (field observation): (Key: PT for teacher; S1, S2 ... for different student)

S_1: (Holding her worksheet up) Teacher (wanting teacher to look at her work).
PT: (Holds the students worksheet) … Which things have you written that float?
S_1: Feather, matchstick, wood, plastic spoon (in a sweet, soft and clear voice … said fluently).
PT: Very good … (Turning to another girl … from same group or table …) and what have you written that sinks? (Good strategy by PT to switch from float to sink)

S_2: Stone … spoon... eh … esteel spoon… (PT no response… turns to other girls in the group … pause … looks at girls working).

PT: You also write as they have written … like here you write what will sink … (not all girls at this table had made all entries yet) … yes … and (yet talking to another girl) … which of your things you say sink?

S_3: emm … spoon … em ... fruit.

PT: (in a friendly and questioning voice) … fruit … but you have put it in float.

S_4: Miss it was apple … (lesson transcript)

Most girls successfully completed predicting and recording predictions for at least seven items; namely, feather, stone, matchstick, wood, steel spoon, plastic spoon and fruit (see samples of student work appendix 6) … Each group was then given a clear plastic improvised water container and the objects placed in a small box for testing. Together we managed reasonably well to have the girls to test the items and complete the corresponding columns in their table and collect resources. However, a disturbance arising from the stools and bulky school bags triggered anger in PT (field observation). This provided me with an opportunity to act in the moment of a real situation to model an alternate way to handle it:

PT: (facing the class) Look at these (pointing at the observation column of the data table on the chalkboard) … we put things after checking (meaning testing) … complete them … I am giving you five minutes … drop your pencils … (just then PT noticed one of the girls struggling to screw the stool seat that had apparently come off … PT in an angry voice…) what are you doing? (PT walked to that table… a number of girls at this table start conversing ... noise level goes up ... girls were having trouble with the stools also handling their big heavy bags … (I quietly walked to the table … with PT's permission I helped the girls to get stools and bags in places ... PT (smiled) … (started to help). (lesson transcript)

In the remaining twenty minutes of the lesson, PT asked the girls to observe the pooled data in the table on the chalkboard, similar to theirs, and name the objects that they observed floating or sinking. PT decided to omit the written task at the end of the students' work sheet, as well as her demo, because there was not enough time. After my demo, PT put up copy work on the chalk board (field notes):

Floating and Sinking answer question

Q1. Why does an object sink?

Ans: If the object is heavy for its size it sinks.

The girls got busy copying 'copy work' that merged into students' snack time. While supervising the girls, PT also marked their copy work. (field notes October 31, 2000).

Reflecting: Post-Lesson Talk

R: How do you feel about the lesson today?
PT: Good (stops).
R: In what way or ways?
PT: Girls liked activity and finished copy work...
R: What about not so good things?
PT: Girls make some noise (smiles ... stops).
R: And someone got angry (we both laughed) ... you were good with the girls ... you helped and only once got bit upset ... I (R) decided to help you...
PT: (smiled) that was okay.
R: You could not do your demo ... thanks for allowing me to do my egg activities
PT: Girls liked it ... It was good and I liked them too. I thought you had brought a rotten egg when I saw the egg you put in water did not sink ... I did not realize that you had emptied the egg (laughed and laughed ...).
R: Today girls were also better behaved...
PT: Yes.h
R: For egg activity I was amazed how girls started giving reasons for what they observed ... Miss that one is boiled ... Miss and that one is raw ... Miss water is not clean ... Miss it is bad (the salt water had a slightly dirty look) ... unfortunately I could not keep the talk and the suspense too long since time was against us and I decided to show them neither there was a rotten egg nor a boiled egg that also surprised them ... one was normal and the other just egg shell from which I had carefully removed the contents through a tiny hole that I then sealed ... and the water in one of the containers had salt in it like sea water. (conversation transcript)

The surprise element in the egg activity and its triggering curiosity was also expressed by PT in her journal entry:

> Today Miss Charan brought two eggs and one she gave to me the other one was with her. When she put it in water that egg was floating and a thought comes to my mind 'is it a rotten egg?' But when I saw something sticking on it as if it had gone under surgery then I thought it would be better to keep silent. Then she told that she had carefully removed all the stuff from egg shell. It was really an interesting idea. (September 30, 2000)

Reflections on Three Co-Taught Lessons

R: Since we have started working together what new things have you picked up? Especially from students' perspective?
PT: Students like to do activities.
R: Can you name some?
PT: Floating and sinking that students did at home … they were surprised that potato did not float though apple did float ... girls brought plastic cups and spoons to

show me that they checked at home and did not sink. This they did for the first time.

R: How did you feel?

PT: Good (stops).

R: Which other activity have we tried to do that you had not tried before?

S: Stories ... though poems I do.

R: What do you think about stories in...?

PT: A good idea ... Girls were paying attention ... Usually we have 15 minutes early in the morning called silence reading time during home period to read out selected stories or text.

R: Can we do this in science lesson also...? ...

PT: Depends if there is time.

R: Of course they take time but it is a better way to manage class and interest students ... I think. When do you notice girls getting really restless?

PT: Yes ... but they cannot sit in one place ... they have to do different things.

R: At this age children cannot stay at a particular task too long.
We need to vary the task ... help them gradually to stay longer on task. What are some other ways ... some we have used in earlier lessons ... to keep students busy and interested...?

PT: Read, draw, paint, group activities or poems, demo … writing ... copy work

R: When do you usually give copy work?

PT: Last 15 – 20 minutes … depends.

R: You seem to worry about ... copy work.

PT: Because parents want some written evidence in their (students) exercise copies. Parents do not give importance to the work sheet ... If they do not see written work in their children's exercise book they complain to the teacher that is me. So I have to make sure that I give some question with answers or fill in the blanks in their note books. Because children are young cannot give notes. This is what I think.
(conversation transcript)

PT's responses were often one word or brief. I often needed to probe to know more. With responses like 'that was okay' ... 'nodding head,' I had to make my own jugdement to take these for 'acceptance' or not. Based on my knowledge of PT from the Subject Specialist Teachers Program I had learnt that such responses with a smile meant acceptance. The above segments reveal changes in PT's thinking about knowledge of students at that age and what could work other than just demos to manage them. Copy work was given importance and I saw it as a function of exams that in turn are a function of the syllabus, as PT also expressed after the second lesson we co-taught, "copy work was not done ... I worried about how I will complete my syllabus if this continued like this." Upon my checking how far behind the syllabus PT was, she responded, "one

lesson." I then asked, "How do you suggest we make up for it?" ... PT, "I will ask the class teacher for an English period." This she did and we had an extra lesson.

Though PT appreciated and witnessed the benefits of innovative ideas, there was always this tension of copy work and goal to complete the syllabus that came in the way. It made me question my deliberations and how they were being perceived by PT. On December 01, 2000 I was pleasantly surprised to hear from PT an appreciation of it:

(Key: R for researcher; PT and Nina group members)

PT: We (R and PT) had done our planning and teaching and we have changed and added many new activities … concept is same but the activities are changed like Ms. Charan have suggested … Some activities which were really challenging we gave it to the children and you (meant for the group) know how our children make noise … but when we gave them the activity children were really involved in thinking to a level that … there was no noise at all in the classroom for some time … Or we can say there was an optimum (acceptable) level of noise as whatever children were discussing was according to the task given to them. Children didn't quarrel … I was really amazed and impressed … I think activity should be challenging as some time we underestimate children and assume that they will not be able to do what we are going to do in the classroom but after this activity I realized that 'activity should have challenge' and we should not underestimate children. We didn't have to face discipline problems where we always have to say keep quiet … keep quiet.

R: (laughing) children are capable …

PT: Ms. Charan has really controlled ... managed my children you just come and see I used to become crazy with these little kids.

Nina: I have never taught young children.

PT: It's is very difficult to teach young kids.

Nina For older children we have to think how to gain children's attention and to maintain it.

PT: When co-ordinator and head observed our class ... says while leaving 'we really acknowledge your effort you are putting to teach these classes' … It is really difficult to teach them (laughs) ... I (PT) said 'you come and teach and we will observe to improve our teaching.' Even they (co-ordinator and head) accept that teaching classes I and II is difficult because here we deal with very young kids.

R: I know it is difficult but …

PT: We enjoy it …

R: Yes we do enjoy it indeed. This is also the time when they (children) need to learn some concepts of subjects like science ... This is not easy but at the same time it is not impossible. I do believe it is possible though a big challenge for the teacher ... to find ways and means to tap on children's interest and the things they like and thus build on that. I have written this in my reflection as well … here (pointing at text in journal) … 'they (girls) like painting and coloring they (girls) like drawing … and we need to incorporate these as tools to communicate with

girls (children) to develop or help children make sense of concepts and new learnings.' (group session transcript)

CASE TWO: SAIRA

Prior Experiences and Initiatives

Unlike PT, Saira did not seek her head's permission to engage in co-teaching and to make any desired changes to her schedule. I suspect this was because Saira, a deputy head, had a more collegial relationship with her head and, therefore, had more empowerment. Saira's head, who has taught for several years at the primary level and who holds an Advanced Diploma in School Management (ADISM), a joint program of the Institute for Educational Development (IED), Karachi, Pakistan and the Sheffield Hallam University, UK, has been instrumental in supporting Saira's development:

> I started peer teaching with my head in 1999. It was useful way for me for improving my language. She supported me in my language and took some knowledge of science concepts from me. This was the objective of our peer teaching. When she first came to my class different questions came to my mind ... whether I will speak correctly with my students, will I be able to teach my lesson properly and why she has selected me to do peer teaching? But after this peer teaching we build good rapport through discussing and suggestions to overcome 'flaws'... my head is interested to teach science in class five. (Informal conversation Saira September 27, 2000)

Saira has undoubtedly capitalized on the opportunities that have come her way to help her grow and better her practice through reflective practice. Not surprisingly, Saira initiated the post-lesson talk on the exploratory lesson. However, her reflections on this lesson improved with time and with the techniques she used. Saira not only stated the problematic areas, but even moved on to possible actions:

> Time is constraint … I had to achieve all the objectives … I could not … reading process for the students is problem … some got it but most did not get … discussion in some things becomes long … and planning could not be completed on time … so could not give enough time for reading. Students wanted to give answers … but some couldn't ... in other lessons I give incentives like star … today I did not, I forgot. Students some ... are not interested in reading and I try to give incentives. So I am thinking how to create interest in them in reading. Also syllabus is a problem … some discussions become long and we rush to complete the syllabus. (Immediately after lesson self-reflection Saira September 27, 2000)

Later that day, she provided reasons for some of her observations in her journal entry, her worry to complete the syllabus for the exams, and a visual 'Development Cycle' (action research cycle similar to the one shown in Appendix 4) that also showed what action she would take next time:

> Students did not take much interest in reading that is why they could not give correct answers ... lost time in giving instructions repeatedly ... rushing syllabus ... I want to complete all chapters of 2nd term exam with the time period ... next time give them easier reading material to create interest

After listening to the audio tape and our intermittent talks, she had broadened her reflections and had even attempted to formulate research questions for herself:

> When I listened to the tape I could not pick the dialogues of my students ... students were talking together ... may be some students talked in very soft voices ... after asking the questions I gave them very short time for thinking the answer ... I was going fast ... I was saying repeatedly also instruction not clear where I have wasted time. How can I save my time more? How can I make reading material more interesting for them (students)? (Saira's Journal entry October 14, 2000)

Co-Planning and Co-Thinking

Planning

As a follow up to her reflections and to further guide her planning, I questioned Saira about possible reasons for her students not taking interest in the reading tasks. We had this conversation:

Saira: Maybe they not like to read ... maybe it is difficult ... it is my opinion.
R: (To tease her mind about her 'maybe' list I added some of my thoughts) Maybe the task was not clear to them ... maybe time allowed for reading was not enough ... maybe because they were only to read and not to apply it to a written task ...
Saira: For next time I will try to think or make another activity sheet... to create interest among students to reading task.
R: Good idea ... do think about instructions also ... what instructions to give? When to give? ... better still write them down ... once the students begin reading task they need fewer interruptions and the teacher needs that time to monitor student progress and guide them to stay on task ... and one more thing ...
Saira: Social skills ... (conversation transcript September 29, 2000)

Saira took responsibility to think about tasks and strategies that would interest and involve more students as well as manage time. Accordingly, she modified her previously prepared lesson plan on the subtopic 'transparent, translucent and opaque materials,' that she was to teach the next week on October 11, 2000. Her written lesson plan was still in four parts: stimulus activity or motivation; hands on experiences; introduction of terminology (transparent, translucent, and opaque) with a written description of each term; and students demonstrating learning of the new terms. However, the modified plan had the following improvements:

a) There were written instructions in English for the teacher for the stimulus activity as per the example below:

Teacher will explain students to work in pairs on each table, observe each picture carefully and discuss it ... 'can see clearly', 'not very clearly' or 'not at all.' Teacher will distribute worksheet No. 3 to each pair ... students will observe and discuss ... teacher will summarize student observation by completing the grid (the grid with four columns 'picture' ... 'clearly' ... 'not very clearly' and 'not at all' was also planned in advance by Saira and drawn immediately after teacher instruction) on the blackboard with student involvement.

b) The stimulus activity and the hands-on experience task were neither teacher directed nor demonstration activities as per the previous lesson plan. However, they were planned and prepared as small group interaction activities followed by whole group sharing. The move from demonstration to class activity, as I later learnt, was partly influenced by one of our project group session discussions on 'is demo the only strategy to be used?'

c) Instead of calling the students by name, Saira assigned each group member a letter of the alphabet as a strategy for calling upon different students to participate in the class discussion. Saira's reason for this was to give a fair chance to every student.

d) Unlike the previous lesson, where Saira checked for student learning by asking them to give examples from the lesson, she also assigned a 'home activity' this time to be followed up in the subsequent lesson.

e) Technical terms were only to be used after the students developed the concepts through concrete experiences using simpler and more familiar language.

The stimulus activity sheet had pictures of events or situations which the students were to classify as cases of can see through ...'clearly'... 'not very clearly' ... 'not at all.' In the hands-on experience task, students were to group the given concrete objects (pieces of cardboard, wood, clear plastic, thick milky plastic, tissue paper, frosted glass, water in a jam jar bottle) into the same three categories: can see through 'clearly'; can 'not very clearly'; and 'not at all.' For a test, the students were to look at a candle flame through each object. The purpose of the two tasks was to guide the students to poster descriptions and then introduce the terms in italics:

- Some materials allow light to pass straight through, we can see things clearly through them. These materials are called *transparent* materials.
- Some materials allow light to pass through but scatter it, we can see things through them, but things will look not so clear or will be blurred. These materials are called *translucent* materials.

- Some materials do not allow the light to pass through them. We cannot see things through them at all. These materials are called *opaque* materials.

It was a good pedagogy to move from vocabulary that was familiar to the students to new vocabulary. This was to be further reinforced by the 'home activity' where the students were to test liquids like shampoo, cooking oil, milk, and vinegar and then categorize them as transparent, translucent, and opaque.

Acting

The lesson started well though some student interruptions were noticed; ... Saira either reminded students about social skills with reference to the poster on the wall or by simply observing silence to signal for attention. On the whole, students during pair or group activity were busy and Saira moved around stopping at different tables and listening or asking ... 'tell me this picture' ... 'why you put tick here' ... there was more order in class and pace was reasonable until whole class discussion took place after 'hands on experience' task while pooling the class findings. Many students classified water as 'not very clear.' In an attempt to convince students, Saira carried on the discussion even though some students were indicating to the teacher to look at the lit candle through the water in the jam jar bottle for herself. For some reason, Saira did not do so. However, at a point when students seemed not to agree with 'clearly,' she asked the students to look at a pencil she placed at a slant in a beaker of water. This made the convincing even more difficult. There was confusion in class. Students were observing and noticing an effect not anticipated by the teacher. Saira was unaware of this and the discussion took longer than expected. Thus the rest of the lesson was rushed (field notes October 11, 2000).

Reflecting: Post-Lesson Talk

Saira: (immediately after lesson with a happy and smiling expression) Today lesson was gone accordingly (meaning she completed the lesson) ... gave more chance to students to talk than teacher ... students took much interest ... more students involved in activity ... students followed instruction much better than previous class ... some confusion about transparent and translucent materials (pause).

R: What do you think was the confusion due to?

Saira: Due to rush of time ... (stops).

R: What was the confusion about?

Saira: Water ... students ... 'not very clearly'...
R: Why do you think many students were saying that?
Saira: (silence).
R: ... Why don't we take a look at the candle through water in the jam jar and your pencil set up? (conversation transcript)

I asked Saira to do the jam jar case, with and without water, for herself. Saira was surprised to find that the flame did not look very clear with water in the jar. When I asked her for a reason, Saira was unsure. I drew her attention to the shape of the bottle. We then dicussed the lens effect due to refraction of light that led to the students' observation which did not match with Saira's observation. This helped her to realize the problem with her pencil demonstration, "yes this (meaning refraction) happened there too" (Saira October 11, 2000). Saira had done this activity with her class a number of times before and had encountered the same problem. However, she had never questioned why this was happening. The joint reflection helped Saira to learn the science behind the problem. Saira replaced the jam jar with a clear rectangular container instead. Saira'a increasing knowledge about her students and different pedagogies not only inspired her, but had an impact on her students as well:

> I felt some inner happiness because students gave good responses and followed the social skills very well ... Teacher talked less and students talked more. In this way in the end I didn't feel tired ... I achieved my effort that I make interest in reading materials ... students took interest in reading and showed enthusiasm in activities (Journal entry Saira November 8, 2000) ... Clear instructions very beneficial for teacher in this way she talks less and gives more time to students to talk and more time to their understanding (Journal entry Saira December 6, 2000) ... Activity should be tried out before doing in class (Journal Entry Saira January 24, 2001)

Every lesson provided Saira with an opportunity to enhance her knowledge, particularly, her pedagogical content knowledge. However, three lessons offered Saira a more enriching growth experience than the others because of the nature of the topic, the prevailing situation, and the fact that the students displayed an alternate framework. The topics of the three lessons were pollution, phases of the Moon, and magnetism. Here I will share the findings from the lesson on the phases of the Moon. The other two will be shared in the chapters that follow.

Saira decided to add the lesson on the phases of the Moon as a third lesson to her unit on 'Sky and Space' because the students had previously experienced difficulties with this lesson. Table 5.1 gives the background and insights gained by Saira into the nature of the students' difficulties.

Table 5.1: Background to the Lesson on the Phases of the Moon

Date/Lesson No. and comments	Purpose of the Lesson	Strategy/Approach	Reflections/Comments
October 31, 2000 Lesson One: Sun and Moon of the Unit 'Sky and Space' I (R) was absent from this lesson	To check students previous knowledge about Sun and Moon (Post-Lesson Talk, Saira, Nov. 8, 2000)	I gave students some questions to think about themselves and then share their answers with the rest of the class (Post-Lesson Talk, Saira, Nov. 8, 2000)	I felt they (students) were giving answers orally ... very well ... but they felt difficulty to express in written form. So special focus area in which I will give special attention: to encourage them (students) in written area ... try to increase their (students') vocabulary and write their responses in complete sentences. For next class I have asked them (students) to explore themselves about the topic ... collect information about 'Sun and Moon' or make a story on it and give presentation in class. In this way I will check their pre knowledge. Then give them their content knowledge. After that they (students) will be able to notice the difference between their and content ... book knowledge. (Journal Entry Saira, October 31, 2000)
November 8, 2000 Lesson Two: Sun and Moon of the Unit 'Sky and Space' I (R) was present in this lesson. Unlike previous lessons, I visited, where Saira shared her lesson plans in advance and sought my help, she desired to do it on her own and test it out. However, Saira did share her plan with me just before the lesson. I appreciated and respected this desire of hers. It was a way to help her build confidence and competence	For students: To share their written stories on Sun and Moon To share factual knowledge about Sun and the Moon To know the position of the Sun and Moon in the Solar-System To observe and discuss phases of the Moon (Pre-Lesson Talk, Saira, Nov. 8, 2000)	Presentatiions: Stories Co-operative learning: Group-Learning of the assigned task and presenting it to the rest of the groups for their learning. Tasks: Groups 1, 3, 5: were to read given information about Sun, Moon and complete their partial sentences (see Appendix 7a) Groups 2, 4: did puzzle activities about planets (see Appendix 7b) Group 6 observed 'Phases of the Moon' through given shoe box model and were to complete the activity record sheet (see Appendix 8)	... students had followed the instructions very well. They listened and observed the presentations quietly and asked some questions. *What problem did I face?* group activity on 'Phases of the Moon' ... the given model was not appropriately working. So students could not observe the phases of the Moon properly. In the presentation they (Group 6 members) just expressed about how that model is made but couldn't tell about ... the cause of phases of Moon. ... Ms Charan (R) suggested it was difficult and challenging task ... needed more time and guidance. So this abstract concept needed more attention and time as compared to the other activities (other group tasks). She gave me suggestion that maybe in the next class I (Saira) could prepare six models and give chance to every student to observe and share their ideas ... we felt that in this lesson other students also wanted to observe. I will do this activity again in my next class ... with all groups. (Journal Entry Saira, November 8, 2000). I (R) offered to co-teach the lesson on 'Phases of the Moon' with Saira. This was acceptable to Saira.

Saira's reflections are thoughtful and demonstrate her increasing concern for her students' needs. She has shifted to more of a constructivist approach perhaps without being aware of it. Saira was pleased with her second lesson. Her consistent efforts had made a difference and her students were responding and learning well. However, Saira had an area which required further probing to help her take further action and pay more attention to the learning of the science concept as well:

R: Today you had good ideas and activities that were working ... but I felt one task ... was difficult for the students.

Saira: Shoe box task ... it needed much more time ... apparatus was not working well. Also there was only one set of reading material for the whole group (seven students) ... it was more difficult.

R: I noticed too students were having difficulties in making observations and also recording in diagrams. This group I think could have done better with more help and guidance. What did you think about students' concepts about the Sun and the Moon?

Saira: I felt they have interesting things and misconceptions.

R: For example...

Saira: One student said Moon revolves around the Sun ... another one said no it doesn't revolve around the Sun but around the Earth ... another said when we are sitting and travelling in a car we see Moon come with us. So it means Earth is rotating one way and Moon rotating in the other way. (Post-Lesson Talk, transcript November 8, 2000)

As evidenced from Saira's reflections (see table 5.1 above), her practice has no doubt continued to progress even more towards student-centredness. As for the students' conceptual learning, this was a new beginning. This was the first time she actually talked about misconceptions and, that too, with specific student examples. In her career story (see page 56 above), Saira had stated the three 'how' questions which guided her practice in the interest of the students, 'How can I create their (students) interest in the topic and How they (students) then can relate the topic to their surrondings? How can I help to develop skills in them?' She was now ready to add one more 'how' question, 'how can I help students to clarify their concepts?' Saira felt that doing the 'Shoe Box' activity (see Appendix 8) once again with all the groups and following it up with a discussion would help to clarify the students' understanding of the concept. Saira's decision to reteach

'Phases of the Moon' opened up an opportunity for me to have her examine other relevant representations or student activities to make the lesson even more effective and contexual. Her willingness was expressed by the phrase 'I am always looking for ideas.' This encouraged me to share a resource with her to add to her repertoire. Saira did not just accept this or other ideas, but personalized them by adapting them according to her student diversity and needs: (Key: R for researcher and Saira for the group member)

R: I have here Quranic Index about astronomy in Quran (holy book) and some are about Sun and Moon. I hope you will find it useful.
Saira: Of course, when I recite Quran I will pay more attention to these ... modify and bring in my class to create more interest about this topic.
R: Are all students in your class with Islamic background?
Saira: Except for two ... (Saira named the students)
R: These sound hindu names.
Saira: Yes, but they can share their own religious aspects.
R: (Later in the talk) Where did you get this idea of ... sorting and matching the two parts of each sentence from the given mix up of sentences on a topic? ...
Saira: From our last meeting ... you said something like ... missing sentence in the activity sheet or incomplete sentences ... that helped me ... also ... my previous experiences ... like missing parts of a digestive system in diagrams where they have to match organs ... (Post-Lesson Talk, transcript November 8, 2000)

Invitation to Co-Planning and Co-Teaching
Planning

As we proceeded to talk about the next lesson on Phases of the Moon, Saira expressed that her purpose of the lesson was "to give boys opportunity to make observations ... and help them (students) to clarify the concept 'phases of the Moon' and I wish to practice my questioning/answering skills ..." (Post-Lesson Talk, field notes November 8, 2000). I offered to co teach this lesson with Saira to help her out with group work and whatever she felt comfortable to assign to me. She invited me to co-plan and co-teach with her and, more specifically, to help her with questions, resources, and practical experiences. I shared with Saira ideas and resources that had worked for me and other teachers and that were relevant to the context, the topic, and Saira's purpose. By November 24, 2000 we had a plan ready for this lesson (see table 5.2 below).

Table 5.2: Joint Lesson Plan: Phases of the Moon

Event	Purpose	Strategy/Resources	Approach/Procedure
Motivation Responsibility: Saira	Making links with: a) the previous unit on 'Light' b) the day's lesson	Question/Answer: **a)** How do you see the Moon? b) Do you see the Moon the same way every night?	Whole class: Teacher lead a) with student involvement complete a ray diagram on chalkboard to recap the main ideas involved. That is, sun's light falls on the Moon, bounces back or is reflected, enters our eyes and from eye a nerve takes the message to the brain and we see the Moon. b) Elicit student responses and make a transition to 'Shoe Box' activity through 'what causes the phases of the Moon?'
Shoe-Box Task Responsibility: Saira; R assists Group work	Students to make observations and record them in the work sheet	Use of Analogy: Model (see appendix 8). This activity page was not given to the students like in the previous lesson since it was found to be problematic for them	Since the model had already been introduced by group 6 in the previous lesson, it need not require lengthy talk. The main focus is to facilitate student observations through the eye holes particularly 1,2, 3, 4 and 8 (on the side opposite to the one with hole 4) of the shoe box with and then without flashlight, help students to record observations and share with whole class. Any discrepancies to be noted and to be explained in conjunction with the tennis ball demonstration.
Tennis Ball Demonstration Alternate Model to 'Shoe Box' activity Responsibility: R	To help students make visual imagery of relative positions of the Sun, the Moon and themselves on the Earth To help students to make sense of the phases of the Moon in relation to the positions of the Sun,the Moon, and the Earth.	Whole class teacher demonstration: Resources: A human body, a yellow tennis ball or some similar object, a strong light source like an overhead projector or sunlight beam directed through a hole in the window of a reasonably dark room. Demonstration works best in a dark or partially dark room. We partially darkened the room by closing the windows and covering them with big sheets of papers.	R (a human body in this case) to stand in the middle of the darkened classroom facing the bright light source representing the Sun. Then to place the ball (to represent the Moon) on the palm of her hand with arm stretched straight out. Arrange students around the classroom about one to two metres away from her. Have students: a) identify their positions analogous to the 'Shoe Box' eye holes 1, 2, 3, 4, 5, 6, 7, 8; and b) predict 'what they would see as they look at the tennis ball when light is switched on?' c) identify R's position in terms of eye holes and then predict 'what would R see? d) switch on light and have students make observations and randomly share with class e) discuss and explain new moon, half moon, full moon in terms of relative position of the Sun, the Moon and the student as an observer on the Earth. Draw parallels with 'Shoe Box' activity and observations and make also reference to the Wall Charts on the phases of the Moon to clarify and reinforce the explaination and introduce the vocabulary rather the names given to different phases like crescent, gibous, half.
Sighting of the Moon in Karachi: Responsibility: Saira	Students to have real life experiences of making observations and making sense of the phases of the Moon Students to appreciate significance of new Moon for the Month of Fasting	Individual or small group real life study	Home Task: Moon watching over one full cycle of the Moon starting November 26, 2000 during the month of Ramadan (month of fasting) and recording observations in the table provided (see appendix 9). Ask students 'when new Moon sighting is expected in Karachi? and what significance it has?' Introduce home task. Distribute the Moon watching tables one per student, let students take a look, explain the instructions and the column headings and how to use it. Saira opted to do it too and share her observations especially at the beginning of the cycle, by making entries on the table that she was to post in her science lab wall. This she felt would ease students to do a task of this scale for the first time. Thus for the first time Saira was to get engaged in a joint project with her class. She was excited.

Acting

Saira orchestrated the motivation task through questioning and answering confidently and effectively. She even managed to have a ray diagram (see appendix 12h) on the chalk board as a visual representation of 'how we see the moon?' Her deliberate efforts, I believe, were greatly responsible for this. Saira had not just relied on our joint written plan, but had also rehearsed her parts, "I practiced my questions... with my sister at home" (pre-lesson informal talk, Saira, November 25, 2000): (Key: Saira for teacher; S for individual student and SS for students):

Saira: ... here I will draw some pictures (silently draws Sun and the Moon on the chalk board and labels each) … okay here is Sun (points to the drawing of the Sun) and here is the Moon (points to the other drawing) ... so here there are two bodies ... Can you tell me which one is luminous and which is non luminous? (pauses, looks at class ... calls a student).

S: Miss Sun is luminous body and Moon is non luminous.

Saira: Right and (while drawing an eye on the chalkboard) this is eye ... looking at the Moon. Right? ... You said sun is luminous and moon is …

SS: (in chorus) Non luminous.

Saira: Okay. What will happen if I hide the Sun (covers the Sun's drawing with her hands)? Can you then see the Moon over there? (Waits to have hands raised).

S: Yes miss (Student's interpretation of Saira's question is different).

Saira: ... You just imagine (pointing at the Sun's drawing) this Sun hides. Can you see the moon?

SS: (a number of students in chorus) No miss (one students hand goes up).

Saira: (calls the student whose hand in up) ... yes?

S: Miss ... Miss Sun is always there ... even at night.

Saira: Good ... so that means we get light from the Sun ... even at night. And the Sun rays fall …

S: (in chorus) Moon … on Moon (students tend to forget social skills but their spontaneous responses in acceptable noise level indicate they are with Saira).

Saira: (draws three rays from the Sun) first ... the sun rays first strike to the … (calls a student).

S: Moon ... first strikes Moon.

Saira: (starts to draw the reflected rays from the Moon) Okay then where do these light rays go? (pause).

S: Earth ... Earth ... strike Earth (another voice ... falls on Earth).

Saira: (draws reflected rays upto the eye) On the Earth or in our eyes (sudden excitement in class and many students ... Miss eyes ... eyes ... Saira notices two students talking) ... (calls one of the students by name) can you give me your attention? Both of you otherwise you can't understand ... Okay ... the sun rays ... all the sunlight falls to the Moon. Okay ... Then what happens? Can you see the Moon now?

S: Yes miss (some laughter in class).

Saira: Okay. Now these rays go ... (soft voices … eyes ...).

S: into eyes ... eyes. (lesson transcript)

Saira was focused. She used a good strategy of first establishing that the Sun is the source of light by asking students the question 'which one ... the Sun or the Moon is luminous?' She then systematically followed and traced how the rays travel into the eye (for ray diagram see Appendix 12h) and finished with, "in our eyes ... from our eyes it goes to our brain and it (brain) gets the message and we can see the object (Moon)." She then immediately made a smooth transition into the next event with her next key question, "... do you see the Moon in the same shape every day?" The lesson was successfully completed, though, at times, it was rushed. The students co-operated well and tried their best. Even when the period ended, the students were still sitting in their seats wanting the lesson to continue. When I reminded them that the lesson time was over and that they needed to get ready to go to their next class, they responded "Miss we can go on ... we want to learn more." Saira had made arrangements with the teacher of their next class to give us ten minutes of her lesson time in case we needed it. We were, therefore, able to give the students ten minutes to express their thoughts and ideas (field observations and notes): (Key: S1, S2, S3 ... represent different students)

> Miss both of you teach us (S1).... Miss 'Shoe Box' and 'Tennis Ball' activity we can do at home like a scientist (S2) ... Miss this (pointing at Moon Watching Table in hand) we will hand in after one month ... and (excitedly) we see Moon for one month! (S3)... Miss I have gone on my roof and observed the Moon with a telescope and have seen it looks the same but some day some part shows ... and some day more and like that ... I have also seen star near Moon (S4)
>
> (Referring to the print out from internet with full cycle visuals of the phases of the Moon shown for the Month of December ... curiosity triggered question ...) ... how can it be possible ... phases of Moon for December when it has not happened yet (S5)
>
> Miss you said you will come on Saturday ... and you came and you also taught us, thank you Miss (S6). My immediate response was 'Thank you for allowing me (R) to be your teacher.'

Reflecting

Saira's and my positive feelings and appreciation were similar to the students:

> I taught 'Phases of the Moon' in class V. I felt very satisfied because it (lesson) went well with support from Charan (R). We did co-teaching. I was also not well ... I had sore throat, so I had difficulty in explaining but Charan took this part and explained it very well. Students enjoyed the lesson. I observed most students took lot of interest, were excited, took keen interest and wanted to ask lot of questions ... One student told me (Saira) 'Miss you too teach us very nicely' ... they (students) told ... 'we enjoyed very much' ... (Journal Entry Saira, November 25, 2000)

> I appreciated the willingness of Saira and her students to allow me to be part of their small scale science community and share the excitement and surprises. 'Phases of the Moon' was fun and facinating topic to teach and to learn because it opened a possibility to make science contextual and personalized by making connection of New Moon with the month of Ramadan and engage students in 'Moon Watching' as young scientists. Thus going beyond mere text book facts and knowledge. The student-teacher talk around pre thought focus questions on the topic also brought to surface alternate concepts. (Personal Journal Entry November 25, 2000)

However, to complete the task on Moon Watching, the students needed further help and guidance which Saira willingly provided. The students took an interest in and enriched their knowledge about the phases of the Moon through real life experiences and reading scientific information:

> next day some students told me (Saira) they couldn't watch the Moon at all due to very congested houses ... some told ... we might go to neighbours house and observe it. For the alternative to this problem I told them '... you can share with me because I also have this record sheet with me or those students who have recorded their pictures can share with their fellows.' I (Saira) also put some information about 'Phases of the Moon' on the soft board and brought their (students) attention to it. I observed ... that students stood by the soft board trying to get some information from the handout ... one student was copying some information from the board. This means I have tried to create their interest in content knowledge. They also show their enthusiasm. They also want to give their extra time to get more knowledge. (Journal Entry Saira, November 26, 2000)

At a later date, Saira articulated her learning experiences from this lesson in her Grid (see Appendix 5c, Lesson November 25, 2000). She described constructing her own knowledge about an effective science lesson as:

> Follow up lesson became more lively and interesting for everyone got chance to observe and clear concept. In co-teaching teacher became more relaxed ... feel good to get help from other teacher. Good resources (charts, drawings, models, worksheets) and well planned lesson give good influence to teaching. Lesson Learnt … 'How we can involve the students to their surroundings to check their concept easily ... this one month assignment will keep them busy and create interest (for evidence of this see samples of students work: appendix 10)

> Reading extra information ... recording Moon cycle ... models help me my understanding about phases of the Moon ... I learnt where Moon, Sun and Earth can be for each phase... also it help students ... they (students) enjoyed very much (Informal after lesson conversation with Saira December 2, 2000)

CASE THREE: NINA

> I (Nina) was talking to ... told ... these days I am teaching Cambridge class for the first time and have many concerns. It is more challenging than teaching equivalent Matric-classes for local exams. But I am learning a lot being with Charan (R). The way ... she asks questions and discusses ... you have to think. I also then go and look for other books and materials and I do sit and read and do activities and or questions. Only then I ... understand. It is helping a lot ... (Informal conversation Nina, November 25, 2000)

Prior Experiences and Initiatives

My (R's) interactions with Nina since the Subject Specialist Teachers Program and, of late, as project facilitator and group member of the project have helped me to know more about Nina both at personal and professional level.

Nina demonstrated a sound knowledge of biology and a repertoire of ideas, strategies, and representations as well as an understanding of her students. She was well conversant with her strengths and areas needing attention. Nina was willing and open to seeking advice and making a commitment to professional learning opportunities, especially in biology, she wanted to enable her students to become 'life long learners' rather than rote memorizers who would only do well on their exams. As I learnt on October 6, 2000 from her students, this was consistent with their perception of her teaching. When I spoke with them after the lesson, they shared, "we like this way of learning. We can remember more ... longer time ... not like other classes ... rote learning." Nina was always prepared to speak her mind and share her thoughts and experiences both successful as well as problematic with other teachers and colleagues with a belief that 'we learn from each other.' I interpret her belief as 'teachers learning from teachers through formal and informal interactions to form bonds to exchange ideas and generate new knowledge.' This is what I had previously observed working with teachers during the Subject Specialist Teachers Program and this is what was helping my group members as well. Nonetheless, Nina's new assignment had placed extra demands on her. She needed support and guidance (journal notes).

Nina expressed concern about teaching for the Cambridge exams saying, "Cambridge is new ... I have yet to know the whole." My reaction was recorded as follows:

> Nina with twenty two years of experience is expert at Matric Level Biology teaching. Now when required ... to teach a more in depth and breadth overseas biology syllabus with different exam format and type, Nina feels like a novice. She seems to doubt her confidence and claims that she needs new knowledge. (Personal Reflection September 11, 2000)

To me, her case paralleled those of the teachers in Hashweh's (1987) study on the 'effect of subject matter expertise on teaching.' In his study, when his biology expert teachers were asked to plan physics lessons, they showed a less organized understanding of the subject as compared to the physics experts and vice versa. However, in Nina's case, even when the same subject matter was to be taught with different but higher

expectations, it raised concerns and she felt 'a less organized understanding of the information' (Cochran, 1997, p. 3). This was not surprising because the new syllabus required more applications of math and physical sciences, which Nina knew to be areas which she needed to strengthen: "When teaching biology, when it comes to math ... I find it difficult to teach (Nina Conversation November 4, 2000):"

> Particulate nature of matter and it is applied in biology!!! When we did PSTS packages (these resource materials from a UK project called Primary School Teachers and Science, were adapted and used for the Subject Specialist Teachers' (SST) Program) I thought it is physics. But now when I come across it in biology I realize it is not only physics and I ask you questions about this just like my students ask me questions. (Nina Conversation November 28, 2000)

Nina works at a high school whose campus is divided into Matric and Cambridge sections. Each section is further departmentalized by subject, which is typical of most high schools. In this environment, Nina was struggling alone to relearn math and physical science concepts which she needed to teach her subject and to transform these concepts to make them comprehensible for her students through practical and activity based experiences. As mentioned earlier, she was faced with time pressure as well. With only six high school students in her class, Nina had the least discipline problems compared to the other participants. However, in Nina's words 'these students are doing practical and activity work for the first time' ... 'students were unaware of the names, uses and proper handling of apparatus' ... 'students did not read or follow the instructions properly' (see grid appendix 5b). Nina had to, therefore, cope with new challenges.

Nina had access to material resources and technical help at the school as well as moral support at home; what she seemed to lack most was time at school to prepare and someone with whom to discuss her ideas. The project offered her the opportunity to share her ideas, to discuss her concerns, and to enhance her knowledge. In response to my questions about resources and her time for lesson preparation, Nina had this to say:

> ... school library, I buy own good books, I purchase own materials to make visuals ... if I did ask school they will not say no, I prefer to buy own. Lab resources, models, equipments I have access to ... now one teacher (Chemistry A-level) I do discuss with him if in need. My son helps me to get information from various websites. My servant helps me to cut out pieces for puzzles/mind maps. I get no extra time at school ... I do at home. I really do miss discussing with other persons. In the project I can now discuss with you and it helps understanding a lot ... When I have decided and I have determined to do something I ... complete it. Both my sons and my husband acknowledge this. They support me. I cannot teach if I have not understood myself first. I also don't want to leave topics out ... I even try to learn difficult topics myself, then I prepare to give to students. (Informal conversation November 4, 2000)

Co-Working and Co-Thinking

My collaboration with Nina developed according to her work ethics, situation (especially time constraints and the syllabus to be covered), and her convenience and preferences. We worked along these lines:

Planning - Nina preferred to prepare and plan her lessons herself and then share them with me before implementing them. This was done either over the phone or by Nina arranging to send her plans to me. I would respond by phone or return her plans with my written suggestions and/or questions. Nina took this seriously and acted upon my suggestions and ideas, modified them as required, often tested them out, and then reflected upon them again. Not only did I make suggestions to her, but I also shared resources with Nina. Nina experienced many successes. For example, she tested the mind map strategy which I suggested. (See Appendices: 5b Grid Nina, lesson 12/1/2001; 11a) and 11b) Students Sample work).

Reflecting - This was done at two levels, self and joint. In addition to Nina engaging in her own self reflection by revisiting her lesson and making journal entries, I made audio and video tapes accessible to her to further promote her self-reflection:

> I have learnt one of the lessons by watching the video that I should have asked students to put up (ask) questions during presentations (Self-reflection Nina October 6, 2000) ... Listening to the audio tape I have realized, I should give more wait time to the students to give better answers (Self-reflection Nina October 10, 2000)

Self-reflections by Nina were often followed up by joint reflections between Nina and me. Most of the time these were done immediately after the lesson starting with Nina's feelings and then my probing her further about them:

R: How do you feel about your today's lesson?
Nina: My students were doing practical activity work for the first time even biology ... they are doing for the first time. They have no concept of systems and the organs in living organism. On the whole it was a successful lesson...
R: How do you know that they have no concept of systems and organs?
Nina: I thought so (laughs) ... so as they were putting them into levels of organization I thought that they would find it a bit difficult to identify these various organs and link them together ... (pause)
R: Did they find it difficult?
Nina: As they were arranging I could make out that they were easily putting them into levels of organization and finally when they gave the presentations they were

quite comfortable and they were giving the names of various organs which were involved in the systems that they had found.

R: Are you surprised? ...

Nina: Yes, they have not done all the cells ... as I do biology for the Matric section also there we begin with the cell and then we come to the various types of internal structures of root, stem and leaf and with that they understand what types of cells are present in leaf, in stem and in roots and what funtions they perform. Here they had only a conception of one or two cells not all cells ... that is the reason I thought that they will not be able to organize these levels for the plant cell in a proper way.

R: Students often amaze us ... It must make you feel good that your students knew more biology than what you thought.

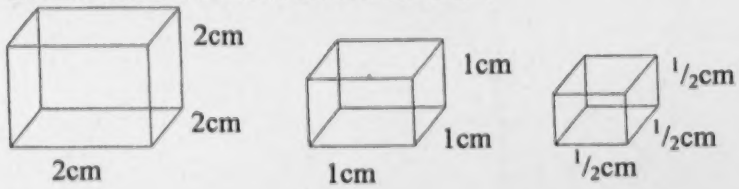
Nina: Yes (with a happy expression) I am learning more about my students. It is helping. (conversation transcript)

My visit to Nina's lesson was usually on Fridays just before noon because Nina's school, like most schools in Pakistan, closed by mid day for *Juma Namaz*, special Friday prayers. As a result, our post-lesson talk time was often restricted. This forced us to be as concise and focused as possible. We discussed any significant after thoughts either over the phone or at a pre-arranged meeting, usually before or after our group session.

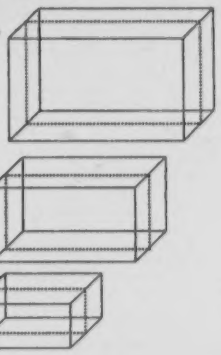
Nina, an experienced teacher, demonstrated her strong belief about the importance of content knowledge, methods of delivery, and knowing about students' difficulties as well as curriculum materials for teaching her subject effectively. Her enacted practice reflected this too. With the new assignment, her struggle was to now strengthen her somewhat shaken confidence. My interactions with Nina were to encourage, support, and act as a critical friend and active participant observer in her class so as to boost her confidence and simultaneously enhance her pedagogical content knowledge. For example, when Nina was grappling with the math involved in the activity 'Surface area is to Volume ratio and it's Relationship with absorption rate' to explain 'Why cells are small in size?' I shared with her a simple and effective alternative that I use:

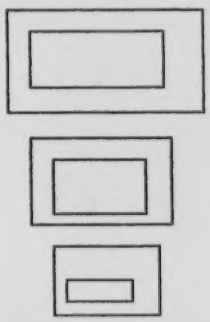
R: I do an activity for this purpose in this way.

- I make agar (China grass) blocks in normal size freezer trays.
- Then from the blocks I cut cubes to three sizes.



- Next I make concentrated potassium permanganate solution in a large beaker (1 L capacity).
- I then soak the cubes in this solution for some time (~ 5 min)
- I remove the cubes and place them on to a cutting board. I ask the audience to make predictions as to what they would expect to see inside the cubes if I cut them in halves?
- I use a sharp knife to cut cubes into halves to expose the cross-session.

Cubes cut in half 

Crossection of cubes 

The students get surprised to find that in the smallest cube the color has gone right into the center, whereas in the other two it has not. I then make an analogy with the cell. Since respiration takes place in the cell nucleus at the center of the cell, for oxygen to reach there quickly to ensure proper functioning of the body a cell has to be small.

Though I had good feelings working with Nina, I worried about making suggestions and giving my ideas. To ease my concerns, I needed to check how Nina felt about this from time to time as part of my moral obligation:

R: Nina what I am suggesting ... I hope you will think through carefully to consider whether or not it is worth it and you are able to do it or not?

Nina: Yes ... I will. It is for my improvement and unless we discuss like this and you guide me also ... I cannot always know ... I will test it. It will be good for next year. (Conversation December 12, 2000)

Nina's appreciation and acceptance of our collaboration was visible in many of her anecdotal remarks. For example:

> Questioning students during practicals ... probing by you (R) proved to be very useful ... which I don't do but I should. I shouldn't just ask students is it okay ... do you have any problems ... but at proper times ask what they are doing and why? ... Ask students to explain ... even make suggestions ... as you (R) were saying students were unfamiliar with apparatus ... I should at appropriate times familiarize students with apparatus used and biological terms
>
> ... this project I am able to discuss ... it is helping me to understand even better. I feel more confident. It has added to my ideas and activities. I can also now think of modifying the activities

like for example the one given on page 31 of the activity book 'surface area is to volume ratio and its relationship with absorption.' Do it myself first and then have students to do or demonstrate it. But I prefer students to do it themselves and then have them explain their observations.

GROUP SESSION SHARING AND LEARNINGS

Reflecting on the Past

Nina's bold comment in our group session on January 12, 2001 'Charan (R) has been living in western culture that is why her working style is different' prompted me to share my journey of growth as a teacher educator since the forties. This stimulated a conversation which revealed the change in our relationship since the early nineties (group session observations): (Key: R for researcher; Nina, PT are the group members; for today's session Saira got delayed)

R: I have grown intellectually, culturally, emotionally since the forties with experiences both from the East as well as the West to present time. I am fortunate to have had this exposure because I feel it helps me to relate better. However, one thing I have learnt ... is that learning is an on-going (lifelong) process irrespective of where you are. (group session transcript)

Both the partners shared my belief, "yes this goes on till a person dies" (Nina) ... "It is from cradle to grave" (PT). However, we moved on:

R: Since early nineties I am here in Karachi ... I have been working with the AKES system teachers on voluntary bases ... PT you might remember ...

PT: I joined ... school first September 1993 and ... in the month of October our Integrated Primary Curriculum (IPC) co-ordinator ... told all IPC teachers that we have to meet with you (R) and plan ... 'Topic Webs.'

R: Yes at that time I was working as a science consultant and mentor with the team of master trainers at AKES-P's English Language Resource Unit ... since then I have come long ways ... last year I decided to go back to school ...'learning is life long'... and today I am very fortunate to be doing my field work with partners like you whom I taught in 97/98 or worked with since early 90s I feel privileged. (group session transcript)

Reflecting on the Present

Nina: Yes we know each other and have already worked together though you were teaching the course. We have a special kind of understanding with you. We followed the main theory and then practice started ... from here ... our ideas started changing ... (paused)

R: (addressing PT) would you like to say more?

PT: Yes to work with somebody, it is necessary to know each other.

R: What do you mean by getting to know each other?

PT: How we should work! … There should be no hesitation and we should be free to say and talk to each other. (Shares an example) during SST, I often came to Mrs. Pardhan (R) to ask e.g. Madam how should I teach mass to my children ... I never hesitated to come to her, whenever, I got stuck and I never stopped to think that she is my tutor and might feel bad.

Nina: No, in SST in the beginning we felt hesitant ... but in 1-2 months we developed a good understanding. In the beginning we used to be scared ... thinking may be you are very strict and we were not sure the quality of work you would demand from us but once we developed understanding we used to have meetings and workshops with you. (group session transcript)

New Relationship: Community of Learners

R: Amazing!! I didn't know this side of your stories. Now as I am listening I am getting to know more about myself and I understand you more and it gives me a wonderful, satisfying feeling. I had never felt strange working with you I had always felt comfortable, however, at that time our relationship was different ... I was a facilitator you were students but now …

Nina: Now it is different … (pause).

R: How?

PT: Now we are colleagues and partners.

Nina: We discuss everything … if we had problems we were a bit hesitant there (SST) but … here [project] we discuss every thing openly and share everything … Now it is totally different and see we came to you and shared all problems that we cannot do this or that naturally we are learning.

PT: And we discuss freely there is no hesitation.

Nina: You are doing your own work … studying and learning and we are also going through the same cycle. We are not going to get a degree but definitely we are learning.

R: Wonderful!! That was my history my story ... and yours too. It has taken me many years to become what I am today and it didn't just happen overnight. I had to keep working. I still keep on working at my learning.

Saira: (who just made it at the tail end of the talk ... PT and Nina shared 'we are talking about SST in the start we had hesitation and ...now we discuss freely ... expressed her feelings) Yes, indeed we have come closer and ... it feels good. (group session transcript)

PT, Nina, and Saira's openly expressed feelings and thoughts in the above talk pleasantly surprised me. Their words indicate the trust that we have built in each other over a time period. We have become critical friends to work together to 'enlarge the space of the possible' in the words of Davis & Sumara (1997).

Reflections on the Three Cases

PT, Nina, and Saira exhibited diversity and yet, as science teachers striving for professional development in science teaching and learning, they had some common features. They were the best judges and decision makers of their needs whether self initiated or probed. The more they reflected and talked about their practice, the more they appreciated it and claimed that they learnt from it. This enhanced their pedagogical content knowledge. PT moved from mere management concerns to appreciate her students' interests and to realize that management is an integral part of engaging students in interesting and purposeful activities. She even started questioning her own practice that, to start with, she thought was 'satistactory.' These anecdotes from her reflections provide evidence of her development, "I have to improve in classroom management, lowering noise level and questioning skills" (September 27, 2000) ... "in SST program I thought we were trained to complete all the planned work for sixty minutes in the stated time but now ..." (October 17, 2000) ... "to keep the students busy with work the control of class is better and the level of noise was also lesser" (November 21, 2000) ... "I did this actually for the first time and found it easy to comprehend what is attraction and repulsion in magnets" (November 28, 2000) ... "regarding rotation and revolution ... the unit plan which we were following had been approved by ADIPE faculty why then these concepts were not made clear?" (January 9, 2001). Saira achieved her goal to reduce teacher talk and increase student-talk. "There was less teacher talk more student involvement ... students followed the social skills, listened and shared with class ... I could listen to everyone easily ... time allocated went well I had much time to explain them even home task" (Saira's Grid entry December 20, 2000). This enabled her for the first time to pay special attention to her students' alternate frameworks. As well, for the first time she extended her curriculum outdoors through tasks like 'Moon Watching.' Nina, for the most part, was working in isolation. "At school most teachers are busy with their own teaching and preparation ... at home I have no help with content." She appreciated the opportunity to get help and support to cope with her new assignment and to regain her confidence. To think through the best possible blending of subject knowledge, knowledge of students' abilities and understanding, knowledge of curriculum materials available, and knowledge of instructional strategies and representations for

teaching was challenging. It never was as simple as Kagan's stage theory model that advocates that teachers develop sequentially in three discrete stages namely survival and management skills, teacher or content-centred, and finally student-centred. However, our collaborative actions contributed to the establishment of a 'community of learners' ; a community where participants shared their ideas and materials with each other, mutually challenged and supported each other in the teaching and learning of science, solved mutual teaching/learning problems, and participated in reflective inquiry into pedagogical content knowledge of science. This is to say that the community played a significant role in scaffolding (Bruner, 1985a) participants' pedagogical content knowledge development.

Chapter 6
WIDENING THE CIRCLE: CRITICAL REFLECTIONS AND RELATIONSHIPS

This chapter discusses the final formal phase of the project with the teachers at the school sites. It builds on our evolving interactions, relationships, experiences, learnings, and actions from the previous two phases, namely, the exploratory and the collaborative actions. In this chapter I will describe and discuss significant incidences of the participants' personal and professional growth as well as the growth of the project in terms of its membership and involvement with teachers outside the project circle.

The year 2001 started with more surprises, hopes, and very unexpected happenings and developments. The formal teaching at PT's and Saira's schools ended in January and at Nina's school in February. My formal MEd Science Module teaching assignments at the Institute for Educational Development was scheduled for the period January 17 to May 24, 2001. The module had to be restructured, and, therefore, in my role as the module coordinator, I was involved in a fair amount of replanning, preparation, and organization. Consequently, the group members and I had to re-examine our schedules and find alternatives to accommodate our previously established and functioning routines for the project.

Project Group Membership Increases

Saira's colleagues Salima and Samina (pseudonym), both MEd graduates from the Aga Khan University Institute for Educational Development, Karachi, Pakistan, teaching science in the secondary section of her school, joined our project (see Appendix B for written consent). Salima, the head of secondary science, was responsible for the professional development of her science teachers. Samina, the head of the secondary section with a strong science background, was involved in the professional development of teachers at her school as well as external to her school. Salima wanted to participate in the pre- and post-conference talks with Saira, as she felt this was an opportunity to enhance her mentoring skills: (Key: R for researcher; Saira for Saira; and Sal for Saira's colleague Salima)

Sal: You have given me three important messages today ... to be very patient when you are working with teachers because they are as important as you are in their position ... you listened to Saira very patiently ... the important thing that you did, you probed Saira a lot like for ... (pause).

R: like for example.

Sal: for the 'burying of paper in ground' one to test for biodegradable or not ... you really ... bring Saira from where she was to a good suggestion which you wanted to give her but you didn't give it before ... it is one of my drawbacks that I tell them ... I really learnt that probe first before 'telling' ... one other important thing ... appreciation really works (laughs in delight). I was listening to you people very carefully ... three times you said 'very good,' three times you said 'I really liked it' ... 'I was pleased.' So these are the wordings, which really encourage teachers to carry on their work.

R: They are like students and like children also.

Sal: And in the way you were communicating with Saira it was so polite and so nice. It's really necessary. ... these sessions are very helpful for us too because here the head of the departments are ... some of them ... are talking in very different tones because they also appraise teachers but ... appraisals are for professional development and you can develop teachers by really working with them so I really enjoyed your session. So why don't you call me...

R: It is important I think, as Samina (the other colleague of Saira) also ... said 'it would be helpful for the teachers' I think we should ... strategize it together with Saira. (conversation transcript January 3, 2001)

Saira and her colleagues recognized the need and importance of their school heads and coodinators to have mentoring skills, however, they envisioned problems:

> the strategies for today you are using for Saira, the heads and the coordinators of our school section can be applying in our own settings ... day before yesterday one of the heads of the department was talking to me that 'I am finding it difficult to give feedback' ... this (meaning sitting in our sessions) is the best way to show how you can give feedback. This is a real demonstration ... (conversation Salima, December 31, 2000)

> ... one more important thing is that teacher ... take positively ... if she want to ... take the benefit of this thing, but not in the negative way. What I want to say is that if we have a discussion so if the teacher take in the negative form ... it doesn't create the situation which we need ... We also observe lessons for teacher appraisal and when we give feed back to the teachers they feel very awkward they think that 'why she said to me like this I am a senior one I always teach right' but if she takes it in a positive way that 'I go ahead and write my reflection and reflect my self and perhaps revise my lesson' ... is ... important ... This should be developed in the teacher that teacher want to do her self-growth professionally. (conversation Saira, December 31, 2000)

Salima's observation reflected back to me my enacted roles as a mentor that I had taken for granted as I was often not sure how I was performing. Saira and her colleagues acknowledged the need for mentoring in a real setting for their school improvement.

Although Saira's lesson for my project visits conflicted with my teaching assignment, she still wanted to continue the classroom visits until the end of January. Saira was unable to move her lesson to another day which was convenient for me. I suggested the use of audio or video tape recordings of her lesson, instead, so that each one of us could listen to or view the tapes independently and then arrange to meet for a joint reflection of the lesson. Since Salima had already joined us for our pre- and post- lesson sessions, it seemed logical to have her assist Saira with recording and capturing significant moments of the remaining lessons. Saira not only accepted this idea, but she even extended an invitation to Samina to participate in case Salima was unable to make it. I was pleased with Saira's decisions. We negotiated to have Salima and Samina support Saira. Samina was more than willing, "it will help me to get insights into my own school students and build relationship across sections" (Conversation January 10, 2001). In my absence, Salima and Samina provided support to Saira. The collaboration that followed opened up the possibility to reach other teachers at Saira's school and, later on, outside her school through workshops that we conducted as a group.

GROUP SESSION SHARING AND LEARNINGS

> What a shocking and least expected ending of the year 2000 and beginning of the year 2001!!! Nina had traumatic experience of at a gunpoint house robbery on December 22, 2000 five days before Eid ... Saira had a minor accident ... sprained her ankle. She can barely walk. PT was down with high blood pressure through out December winter break, Eid and New Year and still is not too well ... In spite of all this they have organized ... to come for the group session tomorrow. I am impressed ... in tomorrow's group session it would help to have Nina, Saira and PT share their experiences and feelings. (Personal Reflection Charan, January 4, 2001)

> ... to day... I couldn't teach in same spirit as I always do. I felt ... blank ... at the end of the second period ... I shared my robbery experience with my students. Many students told me their similar stories and this reminded me of my old experience. One day when school van had come to pick me from my home ... as I came down I did not find the van. After a while I saw the van driver running towards me, frightened and saying 'they threw me out there and took the van away.' It has been depressing for me. I am trying to cope with it. (Conversation on phone Nina, January 4, 2001)

The year for the group members started with traumatic and unpleasant events. To empathize and provide moral support I put 'sharing of holiday's experiences and feelings in the group' as an agenda item. The agenda for the group session had evolved based on our discussions and circumstances. The three main agenda items for the first group session of the year on January 5, 2000 were:

- Sharing of R's pertinent personal reflections, journal entries on *Eid* holiday experiences, and photographs of classroom actions from year 2000
- Sharing of *Ramadan* month and *Eid* holiday experiences
- Strategizing new year's activities, especially school visits for the period January 17, 2001 to February 2, 2001.

Here I will only share the most significant segments of the whole group session that I feel are within the focus of my action research project. I will start with three photographs titled: *The twisted carrots*; *A potted turnip; and The Dancing Dolls demonstration*. These photographs served as focal points for our reflections and discussions on our action research classroom activities. I will then move on to some anecdotal experiences of unexpected events that brought the project group members even more close to each other.

Knowledge is a Human Construct

The twisted carrots (see Appendix 12a):

During the *Eid* holidays I received an unusual vegetable item, a pair of twisted carrots. I have previously seen twin tomatoes and bananas, but not carrots. As I walked to my office with this rare carrot in my palm, it caught the attention of many people. I heard many interesting questions and comments from them: 'How can this happen from one seed?'... 'They are deeply in love' ... 'What a wonderful piece for art?'... 'Nature is fascinating!' ... 'I have been a farmer for twenty years and grown carrots, but never have I grown one like this.' One of the MEd science students even started constructing a theory as to how this could have happened. This fascinated me and gave me an idea. I thought this would be an ideal way to begin my upcoming MEd teaching assignment session on 'how we learn.' I would then collect student responses to illustrate points like 'how our ideas of the same or a common object vary' and 'how we bring our prior knowledge, interest, and experiences into play to respond to a new situation.' Since I still had some time before the module was to start and the carrots would have spoiled, I decided to have them photographed. I would use a visual of them for the same purpose. I was intrigued with my idea and I tested it and shared it with my partners. Nina immediately said, "This visual I can use in teaching the concept of mutation." When I (R) said, "I decided to take a photograph because I did not think carrots would last," PT and Nina began a discussion on how to preserve specimens. Then Saira raised the

question "What made carrots grow so?" Just as I had predicted, my partners had their own responses as well as emerging questions and explanations. I used this as an example to make my point about prior knowledge and children's alternate frameworks and the need for teachers to acknowledge and pay attention to this. (field notes/transcript)

A potted turnip (see Appendix 12b):

This visual with PT's students, was next used to discuss an experience that PT had:

R: ... The photograph shows the turnip that PT and I had grown after our first lesson on 'forces' ... for her class two students ... (The) girls liked listening to stories, (so) we decided to start the lesson on forces with 'The Enormous Turnip' story in which the farmer and others have to struggle to 'pull' the enormous turnip out of the soil ... The word 'pull' is repeated several times in the story. We had brought a fresh turnip with roots and some leaves ... as well. When we ... asked what it was, a number said 'onion.' This I found interesting because turnip is a very common household vegetable. I believe girls probably had confusion about names of the vegetables ... we planted this turnip in a pot. In about one and a half weeks it had grown almost like the one (see Appendix 12c) in the book with the story.' When we brought this potted turnip back to class ... the girls were surprised and they tried to get as close to it as possible ... feel its leaves ... touch it. I better let PT share her observations.

PT: (burst out laughing and in a tone of amazement) Girls were touching the turnip top ... poking hard the top with their fingers ... as if testing 'is it for real.' (group session transcript)

As the group continued to look at the picture of the turnip with the girl poking it (see Appendix 12d), Nina burst out laughing and with a surprised look said, "Ahhhaaa ... Really she is touching ... poking and ... facial expressions are also ... 'surprised' ... 'astonished' as if she is not believing it ... This is also how children learn ..." (group session transcript). This generated a discussion about using visuals and concrete materials, although real is ideal, as aids for descriptions or explanations. Nina made a very important remark 'seeing is one thing ... and listening cannot make the same impression.' This reminded us of the Chinese proverb: We hear and we forget, we see and we remember, we do and we understand. (Group session observations and transcript).

Dancing Dolls' demonstration (see Appendices 12e-g):

The photographs show 'Dancing Dolls' that work on the basis of repulsion and attraction of magnets. PT and I adapted this activity from Tik Liem's book '*Invitation to Science Inquiry.*' The dolls were made from a thin sheet of packing styrofoam and painted. Different sized magnets were used from old radio loudspeakers and earphones. The dolls were suspended from pieces of branches and then mounted onto shoe boxes. A small magnet was hidden under the doll's foot and a stronger magnet was hidden in the shoe box. Two set-ups were made of the activity, one to illustrate repulsion and the second to illustrate attraction. The demonstration was performed at the teacher's table in front of the chalkboard and the girls' eyes were glued to the demonstration. This demo which was the last activity of our lesson on November 28, 2000, evoked the following discussion amongst our group:

Nina: Children are sitting so disciplined...
PT: This is what I was saying little while ago ... 'how can you say it is naughty class!!' By looking at pictures you cannot tell. It is deceiving.
Nina: Pictures can deceive ... but to have them disciplined Charan (R) is standing there too...? (PT ... Yes, then bursts into laughter and keeps giggling and starring at the picture ... as if still not convinced that her girls are disciplined). If they are interested ... then only they will sit disciplined ... the lesson in built here is ... how you can involve them to make them seated like this...
Saira: Yes if there is no involvement then children get bored and we get discipline problem.
Nina: (keenly observing the picture) just look everyone is sitting in place and looking attentively ... one or two not ... but that can happen usually...
R: To have all attentive is perhaps not very normal class...
Nina: Yes, if some ... are not like that then it may look like as if it had been set up and it is not a natural class of normal children. (group session transcript)

Some girls passing by from the class next door were attracted by the demonstration and wanted to come in. To nurture their curiosity, we invited them to return during the break. This low-cost activity, like many other low cost discrepant activities, has always appealed to the audience every time I have used it (field observations/notes):

> Charan shared with us activity of a dancing doll ... It was amazing to see the low-cost materials used with magnets hidden in shoe boxes with like and unlike poles to make one doll dance and the other to stand still ... a good strategy for teaching the topic and keeping attention of youngsters. (Journal Entry Nina after group session November 10, 2000)

> ... I made a similar model of dancing doll for my nephews and asked them to predict what the doll will do if I lower the string. They replied 'it will hang.' When I lowered the doll it danced the younger one was amazed and said 'aunty you can make magic, how did you do this?' ... the older fellow was astonished but said 'there is something in the box that makes the doll dance.' It was at this time that I showed them the magnet and told them that they can also do magic with this bar (it was a bar magnet) and can stop the doll dancing if bars are put the other way ... more surprise!! Finally I explained about the poles of the bar magnet and how they behave and mystery of magic was solved and also understanding developed because they said they will do this magic with their friends. A good way of communicating knowledge from one to the other. This is what the project and Charan's feedback is doing to us. (Journal Entry Nina November 14, 2000)

The sharing of promising and tested ideas had a ripple effect and benefited others. The photographs which were taken with permission of the school, the teachers, and the students became yet another vehicle for record keeping, reflecting, as well as sources of evidence. This was appreciated by the group as well and they looked at them from their own professional perspectives:

> Charan showed us some photographs, which were from our lessons and classrooms. In this way we easily shared our classroom situation with each other. I was amazed to see Nina's class strength ... only five students!!! It is really an ideal class. I think she easily manages all things. (Journal Entry Saira January 5, 2001)

> ... ourselves in our classrooms working with our students and these moments were captured .... It was nice seeing ourselves working in the class of which we had never had the opportunity. I think we should practice this often in an activity class and capture those precious moments with the camera. In this way we can have record of our work with the students. (Journal Entry Nina January 5, 2001)

Concurrently the participants became more knowledgeable about some key features of pedagogical content knowledge, namely; engaging children in appropriate tasks, how children learn, prior knowledge, the concept of alternate frameworks, and their implications for teaching.

Shared Experiences: Strengthened Relationship

This was our second item of the day's agenda. Along with our pedagogical content knowledge discussions, the sharing of our personal life experiences from time to time helped us to revitalize our energies and relate science to everyday experiences. In this first group session for the year 2001, I felt a need to include personal life sharings. Some of this has already been shared earlier on in this chapter. I feel our journal entries below will provide a rich description of our personal experiences:

> We had enough to tell one another both good and bad. I ... shared how I had suffered when the dacoity (gang robbbery) took place and I am still under shock. When I went to school ... I was totally blank and did not know how to carry on with my lessons. Time is such a factor that we start overcoming these problems and this is how life goes on. PT discussed about her illness and she really looked sick. Saira had met with an accident and sprained her ankle. But discussing with one another we all felt light hearted and started our work for the forth-coming month. (Journal Entry Nina January 5, 2001)

> Nina and PT had some incidents they looked very upset ... I must be thankful to God to spend my holidays and *Eid* happily and enjoy it ... I also shared my incident that happened on January 3, 2001. I will never forget this night because of wrong treatment. When I went to see the doctor he advice me 'you should use cold compressor ... not hot compressor.' Then I knew and now I will never forget this treatment ... we shared some unusual happenings and faith of the people. (Journal Entry Saira January 5, 2001)

> ...session gave me a good satisfying and closeness feeling ... of trust ... We laughed and joked. The photographs became a focal point for pedagogical content knowledge talk. We encouraged, supported, and prompted ... one another to pitch in. We shared some lesson segments and how ... links can be made across disciplines. Saira's ... hot compressor instead of cold ... opened up a talk about home treatment verses medical treatment, knowledge construction from informal experiences versus formal experiences, scientific knowledge and nature of science. One and a half hour went by quickly and we departed becoming more knowledgeable about one another's beliefs and interests. The departing comment ... was 'sharing has made it lighter for us' (Personal Journal Entry January 5, 2001)

In spite of the unpleasant circumstances we were determined to carry on. We came up with alternatives for individual and joint efforts for weekly classroom practice and group sessions. The responsibility shifted more to the partners, particularly Saira and Nina. Saira was to work more closely with her secondary section colleagues and keep me informed either directly or through her colleagues. This is reflected in her comments, 'I will talk to Salima and let you know' ... 'we (Saira, Salima, Samina) will arrange it' ... 'I will send materials to you.' The partners agreed to rotate the responsibility to coordinate the scheduling of our remaining group sessions: 'Charan was happy that we are taking the initiative for arranging for the meetings rather than she asking us ... it feels good' (Journal Entry Nina February 14, 2001). Nina came up with a suggestion to monitor her own audio recording of her lesson and her after lesson reflections, especially on the days that I could not make it (field notes/journal entries):

R: ... how my next weeks activities go ... then I will inform you about my next visit.
Nina: But I could get my lesson recorded and also send you all the related materials to keep the communication for responses ... feedback.
R: I am pleased you have spontaneously come up with an alternative that you could organize yourself for your own reflection for continued improvement. It would work well for you since you have only small group of students ... unlike Saira. I

certainly like this. I am confident you will manage it. (Post lesson talk January 12, 2001)

The earlier arrangements I had made with PT were workable although we had to make a slight time adjustment, especially for the post-lesson talk. We thus continued our work together. We had celebrated successes in 2000 and we witnessed more of these in 2001.

Our Efforts Did Make a Difference

***Case Saira*: Saira enriches her 'Environment' unit**

My first visit of the year on January 3, 2001 to Saira's school was inspiring. This was the second lesson in her 'Environment' unit. Compared to the presentations two and a half months ago during the exploratory phase, I noticed a significant change:

> Today boys were teaching each other with confidence ... there was less telling and interrupting from Saira ... Boys were proud of their work. As I sat down next to a group they showed me their poster 'Miss ... look .Miss....we made yesterday' ... students asked questions of their fellow students ... challenged ... The most striking incident was Saira taking a back seat in class on student's chair. This is the first time I have seen this happen since I have observed Saira in the past and during the project. (Personal Reflection of second lesson on Pollution January 3, 2001)

After the lesson, Saira shared that sitting at the back gave her a real feel of being a student and allowed her to observe the students from a different level and perspective. She mentioned that the students at that table were talking and, as soon as they saw her approaching, stopped talking and looked in front without her having to say anything. This provided me with an opportunity to connect my practice with research:

> I (R) often use this strategy in class. It is worthwhile to take a back position or even side positions or a position closer to where the noise or anticipated problem is. This enables better class management without unnecessary words. Research also says that when teachers just stand in front of the class they commonly have a V-shaped vision. Thus the students at the back, sides and in two back corners go unobserved or unattended (field obsevations and notes).

What was affecting Saira's practice? Saira explains it in her words:

> ... in this project I got the opportunity of this thing that I go deeply through the students responses ... write my reflections ... what ever students give me as response and how can I solve it ... evaluate it in the lesson and next class ... I have it in my mind all the time ... to do planning my lesson (Pre Lesson Talk Saira January 3, 2001) ... From the beginning when I planned lessons about 'Pollution' and shared with Charan (R), she gave me some suggestions, instructions and ideas, which were very useful and gone in my class very effectively. Like my talk less and more chance to students. (Journal Entry Saira January 3, 2001)

In the first lesson of the Environment unit, Saira had covered collecting and categorizing different materials into biodegradable and nonbiodegradable. This was followed by a discussion on recycling. The students were then assigned a December vacation task 'How can we save our environment?' After the vacation, Saira was both pleased and surprised by the follow up from the students:

> I was happy to see most of them had ... completed worksheet on the task ... they said they enjoyed it ... but felt they needed some cleanliness in their areas. When I asked them, 'How do you think we can clean or save our environment?' I got much unexpected answers: Miss, people clean their homes but not outside (S1); Miss, if we will ask people to keep place clean they will say are you street cleaners? (S2); Miss, if we say no (meaning not to throw litter) will people listen to us? (S3); Miss, even the *jaamaadhars* (street sweepers) laugh at our talk about cleaning ... (S4). (Pre Lesson Talk Saira January 3, 2001)

Saira then tried to motivate her students:

> may be your actions can motivate them (public) ... when they will see you doing all this they are likely to listen to you ... all these people are not aware of all this but the more you talk to them about it they are likely to listen to you. (Pre Lesson Talk Saira January 3, 2001)

At the end of her discussion with her students, Saira was pleasantly surprised to find out that they (students) showed interest and wanted to take action, "Yes, Miss, we are going to try and make some posters to clean our school environment. We want to do something."

As a follow up to this discussion, Saira then assigned group tasks on 'How to control pollution' for the lesson on January 3, 2001 which I was visiting. The tasks were activities taken from *Teachers Timesavers: Environmental Studies*:

- Journey to school ... a survey project 'by what means people in the class travel to school'
- Air pollution ... picture analysis 'identify where pollution is happening and suggest ways to prevent air pollution'
- Traffic survey 1 ... recording, tallying and totaling the vehicles seen 'conduct a survey of the traffic near school'
- Traffic survey 2 ... using information from Traffic survey 1 'which type of transport is most common?'
- Pollution ... free writing: 'pollution' writing paper (field notes/observations)

As we had agreed in our planning, Saira was to assign the students a greater responsibility of completing the tasks. However, she had to provide them with the proper

guidance as well as support and monitor their progress and needs. Although the activity sheets were unfamiliar to the students, they did a wonderful job (see Appendices 13 a-c for students sample work) with help from Saira, their family, and their friends. They presented their research findings and information with interpretations of the visuals and messages according to their own culture, context, and understanding (field notes/observations). Saira shared her reflections and feelings on the student presentations and the unit:

> It was unexpected for me they came with marvelous preparations ... They (students) gave their presentations very confidently and enthusiastically. Most students listened carefully and gave their comments or suggestions.... they're trying to defend themselves, they tried to convince other students who were asking questions ... according to their own knowledge. Charan (R) also ... said 'they have many good ideas ... are full of resources with support from you (Saira).' After this lesson I felt now I achieved many of my aims. Like less teacher talk more student involvement with discipline and good attitudes. Also students follow the instructions and try to follow others. (Journal Entry Saira January 3, 2001)

Saira's changed science teaching had a contagious effect on other science students and teachers at her school:

> The students of parallel class section also got inspired and asked them (Saira's students) 'what are you doing? We did not do these things in our class.' So I shared my planning with their (parallel class students) teacher and said 'if you want to do it please use it. I also told her if you want to do this project we can discuss on Friday so she appreciated or she took it positively but the negative point is that she has resigned. (Journal Entry Saira January 3, 2001)

As anecdotal evidence to support Saira's and my observations, below are some selected events from the lesson.

Less Teacher Talk, More Student Talk

An example of 'less teacher talk, more student talk' is illustrated in the following example from the presentation by the first group of students on modes of transportation and pollution: (Key: S represents student; Saira represents the teacher)

Saira: (calls first pair of presenters) Okay, first of all I would like to call group one A. (addressing group one A, as presenters walk to the front) When all the children listen then you start.
S: (one of the presenters) My topic is air pollution and my name is X and my partner name is Y ... my topic is air pollution (pause)...
Saira: Tell us what you have done on the sheet?
S: The fuels, which come from the vehicles, which are passing so, it is harmful.
Saira: Can you first read your instruction ... please?

S: Look at the picture below and see where the air pollution …is

Saira: So you just marked the air pollution ... where is the air pollution happening in this picture? You had just marked it ... okay ... then.

S: (shares the group thinking about the picture by reading the written text from the poster) we are going in twenty-one century. In eighteen and seventeen century people are very lucky in that days there no factories, engines, airplanes, cars, buses ... In our time very difficult because every where smoke, dirty water, chemicals, cigarettes. In these days everywhere outside houses very, very noisy, smoke, shouting. We are very unhappy in these days ... but these things are very necessary for every one every thing ... for you cannot go any where if no cars, motor cycles, bus ... goods cannot carrying easily except truck, tractor etc. So how we can decide pollution is very bad thing?

Saira: (the presenters walk back to their places ... smiled and sat down) Okay ... One thing I would like to remind you that every group should take three minutes and (addressing the time keeper) please remind us ... (calls next group).

Excellent brisk start. Students were well prepared and finished their presentation within the allowed time. They read the text in English confidently and left the audience with a technological question. Vehicles pollute our environment, but we cannot do without them. Therefore, how do we decide about it? Every presentation after this was well done. Saira displayed improvement in several of the pedagogical content knowledge areas, particularly developing the curriculum in accordance with student responses, increased student participation and engagment in real life experiences. (field notes/observations).

Students' Science Alternate Framework

The segment below is from the presentation by the second group on their 'pollution' task: (Key: S1, S2 ... represent different students; Saira represents the teacher)

S1: Pollution causes by ... things like fire ... cigarette etc. It produces from the fire smoke ... the fuels of the vehicles ... the cigarette. Carbon dioxide is very harmful for us it is very dangerous thing. Why we do things, which polluted our world?

S2: The answer is ... we made these types of things, which polluted our world. So we have to be responsible and take a promise to ourselves that we have to clean and clear our environment.

S1: Miss plant is necessary to finish the pollution. Carbon dioxide is very bad for us and plants absorb carbon dioxide and give oxygen in the air ... plants clean our environment ... we must do such things ... have plants that keep our environment clean and clear.

S2: not plant but it is tree that takes carbon dioxide.

S1: *Woo saab plants hootay hain* ... (Miss all these (meaning tree also) are plants).

S4: It is from a plant that we get a tree.
S3: *Nahin* (no) … plant ... Miss *podaay* ... (Miss plants) emm.
Saira: What is the difference between plant and *poda* (an Urdu word for plant).
S1: They are same.
Saira: Yes ... Good we will find more about these questions later (calls next group). (lesson transcript/field observations)

The students knew that carbon dioxide is harmful and that plants help to reduce carbon dioxide in our environment. They suggested that having plants would prevent pollution. However, there was a debate about the concepts of 'plant' 'tree' and '*poda.*' The students had a misconception about trees not being plants which Saira noticed and handled well without making the students feel they were wrong. It was good to see one of the students helping the other students to clarify their understanding while Saira played the role of an active listener and facilitator. It was also encouraging to hear the students use more English than Urdu compared to the beginning of the project. I think this was a result of their written work being completed in English, though it was not perfect. In addition, Saira had been encouraging them to speak more English. However, I noticed that whenever the students switched to Urdu they were more fluent, spoke faster, and constructed longer sentences. This signified to me that competency in language does make a difference. Interestingly enough, this pair of students had chosen to present in alternating languages. First one of them spoke in English and almost the same message was presented by the other student in Urdu, a strategy we often use at my institute for everyone's benefit. This example illustrates that students can come up with innovations too, if given the opportunity. (field observations/notes)

Pedagogical Practice versus Cultural Practice

The third group of students was to analyze a picture with: fumes coming out of chimneys; thick smoke from road traffic; fumes from a plane; fumes from a tractor on a farm; a farmer making a big fire; and a plane spraying the farm. The group had to mark each place where air pollution was happening and to suggest ways of preventing it. Their presentation lead to an interesting discussion that reflected cultural and contextual aspects (field notes/observations/lesson transcript):

S: ... we should not make a chimney in our home ... and invite too many people because it creates pollution from smoke and ..: we have liver problem (celebrating occassions with big gatherings and festive meals is a common tradition in Pakistan).

Saira: We should not invite the guests?!! (Traditionally it is unthinkable)

S: No, Miss, we should invite them occasionally because if we invite them often and many then more dirty smoke will be let out and it creates more air pollution.

Saira: For the guests, as a gesture of hospitality you have to cook some thing, right? (questioning)

S: Yes, Miss, can make fire but keep it slow so not too much smoke come out to make more pollution (analogous thinking to 'driving car slowly prevents pollution' given by one of the student earlier on ... interesting).

Saira: ... Okay in your picture where else is air pollution happening? (lesson transcript)

Saira intends the group presentation to move on, but a student takes the talk back to banning big gatherings and a lot of cooking to prevent pollution:

S1: ... whenever there is any marriage at someone's place, then thousands of guests come, so how can it be possible to say cook less ... or slow?

S2: ... order food from out side (traditionally unacceptable). (lesson transcript)

Student (S1) seems to think that by ordering food there will be no smoke produced at home, hence, there will be less pollution. The student has not realized that even if the food is prepared away from home, a fire will still be made and smoke produced. Another student suggests that if the food were cooked slowly, less smoke would leave the house and there would be less pollution. The students have interesting intuitive thinking. That is the thicker the smoke or the quicker the smoke is let out, more pollution is caused. Whereas, if smoke is not very conspicuous and is let out slowly over a period of time then there is less pollution. As one student says, "Start cooking early to keep the fire slow ... so that there is not much pollution" (field notes/observations/transcript).

Saira created an inviting environment for her students to share their personal cultural knowledge constructs with confidence. Saira respected students' ideas and challenged them to revisit their existing knowledge during their next task 'your action.' Saira employed another effective strategy to engage her students in their own learning.

Students' Display their Constructed Understanding

When I (R) stepped out of my car for my next classroom visit with Saira, one of the groups of students met me and eagerly showed me the poster they had produced. I asked them to share what was happening in their poster: "Miss, this (pointing at a set of drawings on the poster) motorcycle and auto-*rickshaw* give out too much smoke and it pollutes the environment. (Pointing at the other set of drawings) Miss, bicycle and boat are having no smoke." I was impressed by the students' work and we had a short conversation (field observations/notes):

R: What about this car (pointing to my car) ... which side should it go? 'Having Smoke' or 'Having No Smoke?'
S: Having smoke, Miss.
R: Emm ... so I have been polluting the environment. I wonder if I could have taken a bicycle or boat! What do you think? (students smiled ... women riding bicycles ... not in Pakistan) Had I taken a bicycle then with the time I had I would have been late to come for your lesson.
S: Miss, bus.
R: But bus is having smoke too.
S: Miss, more people have to go.
R: Sure in that case there would have been one car less on the road, but the problem is where I come from it is far and buses are rare on that side. Also I have many jobs to do and for that I have to go from one place to another in short time.
S: Yes Miss ... this has to be considered. (field observations/lesson transcript)

Talking to the students was wonderful. It was the best way to learn about how and what they were thinking. Our discussion made them realize that they need to consider other factors also when thinking about preventing pollution. However, this group surprised me during the lessson when they used my case to make an argument (field notes/observations/lesson transcript).

After the group presentation on 'Traffic Survey 1,' a heated discussion began on alternate modes of travel. During their fifteen minute observations of traffic outside their school, the group had recorded ten cars with one person in each car. Likewise they had recorded for trucks and other vehicles too. They concluded that their main road by the school was very busy with too much traffic. The vehicles were letting out thick smoke; hence, it was causing too much pollution. Some of the group suggestions to prevent pollution were: instead of driving a car giving out thick smoke, the person should take other transport, for example, a bicycle; instead of one person in each car there should be

more persons in each car ... (some students made gestures as if they wanted to say something). (field notes/observations/lesson transcript):

Saira: (addressing the class) we have time for one question ... Do you have any question? (some hands went up) ... Yes (invites a question from a student).
S: Miss the question rises whether there is one person, two persons or many persons in a car, the car is going to produce same amount of pollution...
Saira: Can four persons be in the same transport that is going to same place?
S1: Yes Miss but the car will produce same amount of smoke whether there is one person or many persons...

In response to Saira's question, the students came up with a number of interesting suggestions, some of which were challenged by their fellow students. For example, 'if there is only one person and car is making too much smoke ... he should ... put the car in parking and travel in ... *rickshaw* or bus' (Sx) ... 'but bus makes too much smoke' (Sy). Sx defends his case 'bus can take many people so less cars on road ... it is better for environment (many students clap as if in favor of the latter idea).' However, the group that I had talked to earlier on made a case for travelling by car using my example:

S2: Miss Charan said that when I come in bus I am late ... it is too far ... If there are important people they have to go far and there is no other transport going that way then they will have to take a car.
Saira: Okay, we have to think about all these things. (students had many things to say and they got excited ...we are right ... no ...) What is right and what is wrong is hard to say ... you all have your ideas (notices my hand going up) now Miss Charan also wants to tell you something...
R: May I say something ... (students in background ... in polite and soft voices ... Yes Miss) I agree that we should try to cut down on the number of vehicles on the road. One way is to share transport. Like for example if there are five people going to same place to work they can share transport. Instead of them going in five different cars they can all go in one person's car one day, next day with next person and so on. At my work some teachers already do this. This way they save energy by saving petrol and there is less number of vehicles on the road.

Some students anticipated a problem with the idea of sharing transportation, 'If a person doesn't want to come or they start quarrelling?' Immediately a student had a solution for this, 'In that case he can go with someone else.' The students had many ideas and thoughts to share, but the time was restricted. Saira brought an end to the discussion by sharing her ideas, "No in this we have to do sharing; all this we will have to

think about ... should we be quarrelling or working together to save our environment?" (field notes/observations/lesson transcript)

Saira had unconsciously ventured into extending her unit on pollution beyond mere textbook knowledge. The students themselves became resource persons to enrich the unit with social, cultural and environmental aspects. This was a new experience for Saira and her students:

> they have not done like this before ... in the previous class ... year ... they just do the pollution and they just do their activities in the written form not in the action form. They have done little bit action work like some people collecting. Then when the lesson is completed they copied it but they don't do like in the extended period. But now I feel that they will do in the extended period whenever they will do with me ... they can do this project. (Post Lesson Talk Saira January 3, 2001)

In the process of planning, implementing and reflecting about this unit, Saira displayed her enhanced competence and confidence of pedagogical content knowledge. She achieved a good blend of subject matter content knowledge, pedagogical knowledge, and curricular materials. Science was linked to the students' immediate environment and was no longer divorced from society. During our conversations about the lesson, we even got into a discussion to extend it to Science Technology and Society (STS):

> When I (R) did sessions on environment with my MEd students ... Salima was in that group, I had them design a tool to pick litter like wrappers, plastic bags and papers without bending and having to pick directly with their hands. ... We then went on a nature walk of my institute's compound. Small groups covered different areas. In each group one person had stick in one hand and a glove on the other to catch the litter to put in the bag carried by colleague. The glove was just a precaution. It was a good way to clean the compound and collect litter that we then used to categorize. Another idea of bringing in technology is designing a tool to pick certain metals. Which kind could these be? (post-lesson talk January 3,2001)

Saira quickly picked up on my idea and made it her own by using her experiences:

> Which are attracted by magnet. But in our daily life we also have seen that some ladies are also doing all these things which ... is incredible. They have some tool ... but they have a magnet and they sweeping this magnet on the soil. So I think if I will start discussion in my class some of the students will tell me about this thing ... very good. (post-lesson talk January 3,2001)

By now, Saira had revised her unit and incorporated new ideas which she got an opportunity to test out. She had gone beyond mere facts and concepts to make the unit more interesting and meaningful for her students. The most significant aspect was 'personalizing and contextualizing the curriculum' (Hodson, 1998) using a variety of representations and strategies. Her students' actions also impacted the other students and

teachers in the school. Unlike the equivalent Canadian curriculum, the Pakistan curriculum lists only topics to be taught. However, it is open to the teachers to extend and enrich the curriculum. This involves risk taking, and I feel that teachers with know-how and support are capable of doing this.

Case Nina: Nina's subject content knowledge struggle ultimately bears fruit

Nina's journal entry on April 12, 2001 illustrates her satisfaction with her progress.

> Today I showed the setting of the examination paper to the previous biology teacher and she appreciated it and said 'now you (Nina) are getting along well.' I felt happy ... previously I had decided to leave the Cambridge class as I thought that I will not be able to satisfy the students. My own learning is not to this standard and I will have to devote a lot of the time for my own learning and undersanding.

Nina had every reason to be happy and, I would say, to even be proud of herself. Earlier on the biology teacher was not ready to make time to help Nina with certain problematic areas of the content:

> I read the topic, but I could not understand so I asked the A-level chemistry teacher. He was quite willing to help. On the other hand the other teacher who was taking biology before me refused point blank that she has no time. (Journal Entry Nina October 27, 2000).

What Enhanced Nina's Subject Content Knowledge?

Believing in self: Setting an acceptable examination paper was an outcome of Nina's devotion, commitment, willingness to collaborate, and being open-minded: "Since I have started working with Charan I have realized that I have become open minded and have started sharing my work with other teachers" (Journal Entry Nina November 20, 2000). Most importantly her success was a result of her own responsibility and action:

> ... I have planned and set the final examination paper. Though I was slow and missed a lot of my working periods, yet I was able to cover most of the syllabus ... but with support ... I have realized how to utilize time effectively and properly with proper preplanning and preparation. Also to be aware in advance when the classes will not be held by reading the notices and keeping in touch with other teachers to know about the extra curricular activities. Though many a times it is difficult. (Journal Entry Nina March 30, 2001)

For Nina to come this far was not an easy process. She chose to take an approach which was strongly influenced by her belief to teach for understanding and for this she herself had to understand the material to be taught. Consequently, she considered herself

to be different from many other teachers as she believed in applying herself and seeking help as and when opportunity opened up. This, she felt, was the secret to her success:

> I had a discussion of a few topics of biology with other teachers at a ... workshop ... I was surprised to find that many of them were not teaching the topics in sequential manner and they were skipping exercises that they did not know and told the students they will do it some other time. I was surprised to hear such things because I am a person who would learn and understand by reading or by asking somebody before teaching my students to keep student's confidence in me. ... the facilitator of the workshop gave us 1998 Cambridge Past Paper to solve ... From 10 pm to after 12 midnight I was busy solving the paper. A few questions on graphs posed problems for me I just guessed the answers. A few I left unanswered. Next day when the facilitator put up the answers I was happy to find that most of my answers were correct including the graph, but that was by fluke ... not only I had this problem but many others too ... the teacher took time to explain to us graphs and magnification of objects under microscope. Attending the workshop was very useful ... But at the same time I was sorry because my Matric students missed four periods ... when I went to their class they asked 'teacher how will we cover the missed periods?' and 'teacher why were you absent ... you have never been absent?' I seldom miss my classes but I was glad that my students missed me because mostly it is the opposite because students are often happy if their teacher is absent. (Journal Entry Nina November 2, 2000)

Even before going to the workshop Nina took initiatives to prepare for it:

> I kept wondering what I will be supposed to do in this workshop. It is the first one for me as a new Cambridge teacher. I took some past papers to brush up some topics ... I had done ... in the University ... It was bit difficult refreshing myself but I spent two days going over various questions. Cambridge paper questions are tricky and I found that the students should have a good concept of the topic (Journal Entry Nina October 28, 2000) ... I spent my afternoon working on graphs. I found it difficult ... I am sure if I do not understand I will ask the workshop facilitator to explain ... I am still nervous as I am the only one from my school attending this workshop. Now that I have decided then why be scared!!! (Journal Entry Nina October 30, 2000).

A self-motivated and determined Nina put in extra time and effort to enhance her pedagogical content knowledge, specifically the subject content knowledge. Her enhanced subject content knowledge in turn influenced her pedagogical content knowledge. She was very conscious of giving the best to her students and for her students to recognize this. Yet, because of the prevailing exam oriented teaching and learning school culture, she encountered disappointments and had to answer to her style of teaching:

> I told my class that on November 10, 2000 we will be doing an activity using agar (China grass) blocks to understand practically what happens. My students said 'teacher first you tell us about the types of questions for the mid term exams and secondly November 10, 2000 is the study leave for us. I was disappointed to hear this. (Journal Entry Nina November 7, 2000)

> Students shared with their teacher in-charge that I was slow in completing their syllabus and many things were being repeated. Secondly they did not like reading; instead they would have liked explanations from teacher. The incharge called for me and explained the situation in a very polite

> way ... I would like to share one thing that in most schools teaching is more teacher based and this is why students feel uncomfortable with such type of teaching. Today is also our group session and I will share about this issue with group and Charan. (Journal Entry Nina March 2, 2001)

Sharing and learning: Our group session on March 2, 2001 began with the sharing of individual stories or concerns. Nina shared her dilemma without hesitation in a disturbed and forceful tone. She was not her usual cheerful self, beaming and bubbling with energy. She was deeply concerned about the situation she had encountered and wanted to talk about it. I had to be a good listener and respond reassuringly to Nina that she was going through a new experience and that some of these expected challenges are unavoidable. She had already taken a number of steps to face these challenges and had managed to deal with them which demonstrated her ability to cope. Nina's sharing of her journal entry to the group lead to the following dialogue:

Nina: I explained to the in-charge that it was not just a reading but different reading sample packages from different books to help students to know how to reference to other books ... they mostly use their textbook only ... readings were based on the activities they did ... At the end I called students to demonstrate their understanding in a mind map form ... they found the work was too much for them for two periods. What I understood from her (in-charge) is that basically they (students) want a teacher-centred class ... teacher comes, gives explanation/s, they take down the points and ... they are satisfied...

R: Interesting isn't ... how students perceive things.

Nina: ... this is what I was discussing on the way with Saira (to day Nina and Saira had travelled together in the same car) ... Everything is done by the teachers ... because I'm the only one doing differently ... they think that it is being done in a slow manner ...

R: Students look at things in interesting ways.

Nina: I said (meaning to the in-charge) if they (students) want me to do the work quickly ... I'll do it for them ... so that they feel satisfied. More work but with no understanding.

R: ... something to think about. This is very normal whenever there is an innovation, whenever there is a change involved. It is new for the children ... the administration ... I wonder if it could be said that it's completely new ... its just that you expect them to read and think more for themselves (Nina in the background ... yes), rather than you ... telling everything.

Nina: ... I told her (the in-charge) ... 'when I gave them a test ... if they had demonstrated their understanding, why would I repeat. For the activities we did for enzymes, the left over work ... observation had to be made ... that was continued in the next class ... is that repetition or ... continuation of the work?' ... then she asked me ... 'do you know the way the previous teacher is doing ... sit in her classes ... do the observations how she is coping with the work and then you

follow her.' ... I said 'I am ready ... to sit in her classes ... I will see then may be I will teach in the same way to finish the syllabus.' (group session transcript)

I continued to prompt Nina to verbalize her feelings, concerns and, together, we worked out some strategies. The intent was not to discourage Nina from her way of teaching, but to somehow find a balance:

Nina: ... the first one thing that is mentioned in the Cambridge syllabus ... if teaching for the first time then the teacher is advised to refer to the past exam papers when she begins teaching.

R: ... I think there is a reason behind that ...from the past papers you would get a perspective of ... say for example the style of the exam...

Nina: Yes

R: ... also ... about the depth and the breadth ... many teachers who come to teach a new class or course, they do that ... They ... look up the syllabus, the text books that are prescribed and any other relevant materials like exam papers to get better ideas about expectations ... You already have ... the idea what to teach and what is the nature of the exams.

Nina: ... In the syllabus they do mention ... the topics and each topic is divided into ... sub-sections ... we are required to do only those parts. I think students have this misconception also that they have to do this whole book ... Out of that every topic only chosen work is to be done.

R: That is fine. I think because this is your new experience ... there are lot of things that you are discovering and learning ... one thing is to really look very closely at the syllabus ... you already did that for the workshop.

Nina: ... that was the marking scheme. I do follow that.

R: That's good. However, I don't think that can restrict you from your way of teaching (Nina in the background ... Yes, yes ...). You can still do your work with the students and with them taking ... responsibility also. You have to some how balance it in some way.

Nina: They (students) said that other teacher was not doing so many activities like I'm doing. That's what they even said to the in charge, and also that she (other teacher) did most of the explanation and just one or two demonstrations and that too she does it herself. She doesn't like the students to do, they just observe.

R: Obviously your belief and your way of working is different, it is ..

Nina: It is different.

R: ... that doesn't mean that you can totally go away from this ... you have to be very selective. Now that you have more knowledge about your students ... you try to decide what possibly is not that difficult and students can handle with adequate and clear instructions or guidelines. I think we had talked about it a couple of times before.

Nina: Yes that we have ... I can give them the home task ... then I take up that work so that I know that they are doing it ... the main thing ... I have to know if they are

keeping up with work. Mostly when I give them the home task most of them don't do it. (group session transcript)

Support from colleague: Since Nina and Saira had come to our group session together, I capitalized on the opportunity to have them share their experiences with each other in my absence on their way to the session. I had arranged for a tape recorder to be sent to them to record some of their project-related experiences or concerns. Such opportunities are rare for teachers in this context as I have learnt from my experience of working with teachers in Pakistan. Nina took the initiative to share her incident with Saira which became the topic of their discussion. Saira had to listen actively, support, and encourage Nina. This experience was rewarding for me as it demonstrated that the teachers do not always need a person like me to promote their thinking about their practice:

Nina: Today ... in-charge (meaning the principal) said, 'Yesterday I asked the children about biology. What I felt from what they said is that you are going pretty slowly.'
Saira: Syllabus wise?
Nina: Yes slow and many things are being repeated as well. The problem is that the lesson gets stuck ... have to do it again with necessary changes to clarify things.
Saira: Yes we do it after modification.
Nina: Yes and it is based on reading material. Like I had them make mind maps (done for the first time) after reading given materials and do presentations to find out what they have understood.
Sair: Right.
Nina: ... people here are not brought up like this ... here ... teacher comes to class, she gives an explanation, students write down points and quickly complete the lesson ... syllabus ...
Saira: yes ... they complete it (meaning syllabus) quickly.
Nina: What was I supposed to say then? That ... this is the way our classrooms are ... No, I said 'alright now onwards I will try to make them go fast and complete work.'
Saira: Yes ... we can complete quickly ... but this kind of learning...
Nina: These are older students and of course they do get worried that maybe our syllabus may not get completed.
Saira: Yes. They (meaning activities) are time consuming ... certainly take more time.
Nina: ... certainly as in charge ... she has to ask students to get feedback ... I said 'this is the first time ever I'm taking this Cambridge section, it will of course take time for me to get settled in this new situation and find out how to do it in best way to achieve the syllabus objectives.'
Saira: Yes certainly. That has to be thought about too.

Nina: One thing is to tell them most of the things, like the prevailing practice ... if they are to do the activities themselves and find out for themselves ... it of course takes time ... (pause). (conversation transcript Nina and Saira, March 2, 2001)

Saira not only listened to, but even made suggestions to Nina that were very similar to mine, "Yes they take time ... one thing you can do is give home assignments so that they ... get their written work completed ... as much as possible" (conversation transcript). Furthermore, Nina and Saira discussed the constraints as well as the possibilities they were experiencing to promote a change in their science teaching:

> what children want is just to jot down the points ... and memorize them. They don't really care much for understanding or to explore. That's their system. Here (meaning their schools, especially Nina's) the difficulty is that very few teachers do it the other way (meaning through activities with understanding) ... the syllabus is also not in our hands ... All this work we are doing it means to them (meaning administration and colleagues) ... just understand it this way that they don't want this type of teaching, they tell us to apply it here and there. (Group session transcript, Nina and Saira, March 2, 2001)....
>
> The main thing is ... the school system. If everyone at school is in its favor, then it's good. But if not then alone an individual … is hard. First the heads should be made to do these things. Like in our school-system heads do ... ADISM and MEd, when they (heads) do it then only they know about these things. (Group session transcript, Saira, March 2, 2001)....

In spite of all the constraints they faced, Nina and Saira had undergone a change, especially by getting involved in the project:

Nina: She (in-charge) said '... these kids already ... know a lot you make them go fast and have them (students) move ahead.'
Saira: ... other teachers also do this. They (teachers) think that the students ought to know ... but they (students) don't know ... How do we know? The deeper we have gone to find ... we have learnt how limited student learning is...
Nina: If they (meaning Nina's students) knew a lot and the reading material was also in front of them, so the work would have been easier ... they found it difficult...
Saira: That is right. That's exactly what we have analyzed in this project ... Previously we thought that the students know everything (meaning mostly by listening to the teacher) ... but when they (students) ... like explained the things with drawings then only we realized the depth of their learning.
Nina: But they (administration) do not have this knowledge. She (in charge) said 'no problem, you just do the specified topics for the students from the examination point of view.' (conversation transcript Nina and Saira, March 2, 2001)

Nina and Saira brought to the surface the forces against which they have to work. As their conversation progressed, they elaborated upon these with examples that were specific to their context and that they had personally experienced. Nina expressed her

feelings in these words, "The system has become like that and it's extremely hard for us to bring a change in this system." Both Nina and Saira demonstrated an awareness of the way their educational system works and their standing. Both are in favour of change. Whereas Saira is in a better position with more of her colleagues sharing similar views as her, Nina, for the most part, is grappling alone. It was interesting for me to witness a primary and a secondary teacher engaged in a conversation like the one above. I suspect it is the trust and respect between the two that made this to happen.

Self-reflection: Although Nina had the opportunity to share and reflect upon her incident together with Saira and then with the group, she left the group session still thinking about it. My reflection for the day read:

> Innovation or new experiences have inbuilt uncertainty or are unpredictable, while good intention is at work. It may not be perceived or recognized that way because there are many other external forces at work as well. Nina had an unexpected experience to day. She looked and sounded really worried. I let her express herself in the group session. I think it would be helpful to call her to find out how she is doing. (Personal Reflection March 2, 2001)

R: How did you feel about sharing your feelings and concerns in the group session?

Nina: I felt good also I feel the way in charge had brought to my attention was in a good way ... professional and I am glad to learn early enough how students' feel and I do understand I will have to make some changes too.

R: I like your approach. My advice to you, as we had shared earlier on is ... bearing in mind that for students as well as parents, exams are in the forefront ... to continue working along these guidelines:
- Get to know the syllabus: do break-down monthwise, weekwise and finally day wise and possibly lesson wise
- Work as close as possible to the prescribed text book and make reference/s to other books as and when necessary and appropriate
- Take a look at the past Cambridge papers
- Assign tasks from past papers and text book and additionally from other sources ... explore possibilities of employing for example a past question as motivator or stimulus for discussion to incorporate representations and links to appropriate and relevant readings

Nina: I have got a collection of past papers and they are organized topic wise. So I will start using more questions from there. I will assign readings to students in advance and in class review main points/concepts and do select activities. More importantly get students to do questions especially from past papers first and then if need be or possible extend to other questions or activities to clear points.

R: Sounds like a good idea.

Nina: The in charge is right that students are anxious that syllabus be covered and they get some practice ... also that I am new to this Cambridge teaching and that I need to be helped. She said she will come and observe my class sometimes and also advised me to observe experienced teacher's ... Cambridge level ... lessons and

pick some pointers as to how this teacher combines past questions with the learning in class. I will do it. Also it is good that it is now Eid holidays. I am going to work with syllabus, books, past papers, other select reference materials and think of some activities and do the planning for the time remaining until April and May. I will call you if I need help or even just to share.

R: By all means. (Phone Conversation March 3, 2001)

Nina had to go through a process of reflective practice, self and joint, to deal with her tension until she finally internalized the best way to resolve it. This is what helped her to put together a good paper.

Case PT: **PT believes in change but external pressures make it difficult**

PT, a parent preparing her child for a rigid national board exam as well as a teacher experimenting with better ways of teaching and learning for her students, expresses her mixed feelings. In the process, she highlights external constraints to innovations that are beyond school level:

> If we want to bring the change doing activity based (hands on and minds on) it should also be in the secondary. What happens right now in ninth and tenth classes (this is when Matric-students write their National Board Exams), there is almost rote learning. Now the girls that have been doing activity-based learning from the class one till class eight, they find very difficult to rote learn and prepare for the board exam. Do you think this will help those girls? (Formal Talk PT January 11, 2001)

During our (R and PT's) discussion on January 11, 2001, PT raised for me a very legitimate question "Will this (learning by doing) help those girls (grade nine and ten students) achieve high test scores?" This used to be and still is a recurring question during the Subject Specialist Teachers' Program. In this course, we had some participants teaching classes nine and ten. They were very uncertain and, hence, reluctant to test innovations. This group of participants needed a lot more support, guidance, and convincing to change their thinking. Once they actually tested the ideas and innovations with their students, they appreciated this process. They discovered that not only did it make their teaching and learning interesting, but their students received better marks. To answer PT's question I, therefore, felt it more appropriate to cite cases from the cohort of Subject Specialist Teachers' Program in-service teachers:

> *participant W* ... He initially had the same feeling and he was very reluctant, very reluctant. But then he said well 'little bit I can start ... instead of having them (students) just do this problem using formula straight away, I can ... first give them something to do practically ... then come to

> the formula ... I'm going to try.' Do you know what he found? ... he started realizing that he was able to complete the syllabus and also his students were doing better. Today he is a changed person. These days he ... runs workshops for his fellow teachers of classes nine and ten to share his experiences and impact his colleagues ... another example is Nina's case. We often hear her success stories in our sessions. I think it's up to us as teachers. We have to start somewhere ... I agree we cannot change that exam system yet, but we can hope that in the long run we can make an impact ... right now what you are saying I think I do understand. However, I still think we have to make some kind of a balance. As you realize, every time you tell me, 'they have to do copy work' ... I'm not very happy the way that copy work is done ... (PT is heard in the background ... Yes, yes), just fill in the blanks and ... having the students to regurgitate what teacher has just said like for example teacher says 'the shape of the earth is round or spherical' and then askes them 'what is the shape of the earth?' Do you think there is much thinking involved in this way of teaching? (conversation transcript, Charan)

PT acknowledges that teaching for rote learning does not involve much thinking. However, her personal experiences with her own child have made her question her belief:

> Literally no. But we have to look in to students' future also. If we are talking about their future ... what about when they go to the secondary. I have gone through this experience ... my daughter is preparing for the Matric exams ... when I go from here (school) home ... I have to really do a lot of efforts to make her rote memorize because ... she (daughter) says 'Mom you told me in your words and I wrote it in my own words, Miss (daughter's teacher) deducted my marks because she says its not in your book.' I said, 'but my dear daughter, the meaning is the same.' She (daughter) said 'our teacher does not agree.' So when there was a parent teacher meeting I went to see the teacher. She (teacher) said that 'we do not accept it because when the child will go to do Board Exams and if she'll write in her own words then they will dock the marks.' (conversation transcript, PT)

PT has a dual role as a parent and as a teacher. Her own daughter is experiencing difficulty in preparing for exams which enforce teaching for memorizing, and PT finds it problematic for her to help her daughter. This creates tension as her experience with her daughter seems to be conflicting with her beliefs about effective teaching and learning. She struggles within herself about changing her practice when the system offers resistance. Consequently, she emphasizes copy work claiming that she has to prepare these girls for secondary level. Nevertheless, PT would like to see a change, "Change is not easy. Yes, I would like it (change) but the problem, which I am passing through, so naturally I have to look for my daughter to give what ever they (Board Exam Body) are asking" (Conversation transcript PT).

Though I empathized with PT as a parent, I questioned her professional responsibility for her own students:

R Agreed, you have to help your daughter in a way that best works for you and her. But what about your students in your class? What about system?

PT: ... we do want our students to be great thinkers ... But when they go to the secondary, then it becomes a problem ... I would like to prepare them for the secondary that is my aim ... whether they are critical thinkers, they must be such that if they have to ... memorize ... the student should have enough ability to do it.

R: But the way your students are being taught ... we engage them in tasks and think, then their copy work is given ... Do you think this will help them to be able to remember perhaps better? (pause) I know of another educator who did his research in Nepal with a group of teachers. His teachers had very similar thinking and situation like yours. They were resistant to change but ... excuse me for this but I think this is what is coming out from what we are discussing...

PT: Yes (and nods her head ...)

R: ... that you seem to be resisting change.

PT: Yes, yes (and sort of smiles).

R: ... that is why I am sharing ... some cases that seem to parallel with yours. ... resistance ... I feel it does not help. Of course you have your reasons for resisting and that is fine. However, I have noticed change in you and I want you to know it yourself ... okay, these teachers from Nepal once they brought in change they found that their students ... did better on exams compared to the others. I think it helps to hear or read about such cases. Is our way of working making any difference in your class?

In the subsequent discussion I had with PT, she reflected upon some positive outcomes of our joint efforts and the change she has experienced:

PT: Yes they (students) are using their own imagination and they write (pause).

R: What else?

PT: Their vocabulary is improving.

R: Anything else?

PT: They can express themselves.

R: What else what about classroom management, noise in class ... any changes...

PT: Yes by keeping children busy means in discipline there is not so much of a problem ... children do talk somewhat.

R: Narurally that is bound to be otherwise it is not normal class.

PT: It is not possible to keep them completely quiet ... there is improvement in management.

R: What about you're own feelings? Is it helping you as a person in any way? For example management getting better ... in the beginning you said that when girls make noise and do not listen it does affect you? When the girls are making noise ... how does it affect you? What do you do then?

PT: (really laughs) I used to get angry ... even now I do get bit angry (laughs).

R: But have you been getting as angry as you used to?

PT: No (laughs).

R: You have been more relaxed. I have noticed that these days. It makes me feel good. I think it is very important that as teachers we have to look after our health also.

PT: Yes (with a happy expression).
R: It is not only helping your girls but the teacher also. What about their copy work? Has it suffered?
PT: No, it is complete.
R: Do you feel they are ready for the exams?
PT: Yes, they are but I was worrying about their secondary. For these girls surely we have all the activities and tasks ... and things but I was thinking about the secondary.

Working together with PT had made a difference which PT acknowledged on a number of occasions. Our innovations, through careful strategic planning, did not hinder PT's students' copy work and preparation for their exams.

Before embarking upon the project and even during the initial period of the field work, I was skeptical about how the project would evolve. I had anticipated elements of surprises and hiccups which are what happened most of the time. In spite of the challenges in our collaborative efforts, we were able to make differences and significant improvements in the teaching and learning of science through our: common purpose; focus; mutual trust; willingness to be open; sharing of feelings and thoughts; learning from each other. Our commitment and involvement did not stop at the participants' classroom level, but went beyond this. Saira's findings while working with her students during the project became instrumental in our designing and conducting two workshops on the topic of 'magnetism' for some science teachers in Karachi.

CONCEPTUALIZING WORKSHOPS

The idea for the workshop's content originated from Saira's findings and her expressed desire to share her learnings with other teachers, "When I learnt about ... work shop ... I was sitting ... with my students' responses ... I said having researched these ... responses why don't I share with other teachers ... for their benefit" (Group Session Siara March 2, 2001). This happened during the period when Samina was visiting Saira's lessons. Saira shared her idea with Samina, Salima, and me. I was pleased with Saira's initiative and encouraged her to pursue it. However, Samina raised an ethical concern:

> Since I did all the observations as part of the research, I am wondering whether I can use the obtained information for other purposes or not. I know that I have to maintain confidentiality, but still teachers know that I have been to Saira's classes and they may make some inferences even with anonymous sharing. (Personal Reflection Samina Feruary 15, 2001)

My response to Samina's query about using Saira's data to run the workshops was:

> I do see a positive side to benefit more teachers from our experiences of working with Saira. I do agree that confidentiality and sensitivity to the participants in the landscape is of utmost importance to bear in mind. However, Saira has often shown willingness about sharing her experiences with other teachers if the other teachers can get benefitted. We (Saira, Samina and R) could together think of developing some action plan. Let us think aloud and dialogue. (Charan in response to Samina's reflection Febraury 15, 2001)

Saira, Samina, Salima, and I, thus, started working on Saira's idea. By the end of February we had done a fair amount of work and had a plan in mind. As such, we planned to share this new development with Nina and PT at our group session on March 2, 2001. What follows next is the background to the workshops and their success stories.

Sharing Workshop Background and the Plan

As soon as Samina started visiting Saira's classrooms, the students started making connections with Samina. She made observations and began noticing where some of their concerns lay. Meanwhile the Science Association for Pakistan (SAP) approached me asking, 'Could you do some workshops for us?' I suggested to Saira, Samina, and Salima that we put together a workshop on some of the concerns that had evolved during the project. For example, on the topic of 'Magnetism' Saira's students came up with interesting ideas when she asked them to make two separate drawings, one to show a normal magnet and the other a magnetized magnet (see Appendix 14). This surprised Saira, but helped her to check student learning at the end of the lesson. She realized, "some of them still have some confusion. I will ... try to remove their confusion" (Post Lesson Reflection Saira January 24, 2001). During the post lesson discussion, Samina also asked Saira a question on a current carrying coil (an electro magnet with a nail as a core) which made Saira to realize that she needed to stop, think, and read more:

> When she (Samina) asked, 'does a coil of wire have magnetism also?' Then I had to think about this matter. When she (Samina) was gone I went to the secondary library and issued co-ordinated science book to enhance my content knowledge also. (Post Lesson Talk Saira January 24, 2001).

During another lesson on 'Magnetism,' an interesting alternate concept was revealed by the students when indicating current in a diagram of an electromagnet. The students' thinking was that the current passes through the nail as well.

These experiences helped us to identify the difficult concepts as well as some of the problem areas. Samina also identified 'magnetism' to be one of the areas with which she and other secondary teachers have difficulty. This got us thinking and we came up with the idea of exploring the understanding of these and other basic concepts in 'magnetism' with other science teachers also. We felt this to be timely and appropriate for the SAP Workshops. We also felt it could be done without naming the school, teacher, or the students so as to maintain confidentiality. We felt that we could make up cases like, 'A student has drawn a diagram to show how a magnet can get magnetized. How would you as a science teacher respond to this student?' We would use the relevant diagram from a student's work without using the student's name. While we discussed these ideas for the workshop as a group, Nina and Saira in the background were saying, "Yes this is good." During the session, I shared with the participants:

> This way we will be able to elicit teachers' ideas and then build on to that for our workshop. We have thought of ... this month we elicit basic ideas on 'magnetism' of SAP members using a task sheet preprepared and pilotted with Saira and Samina's scince teachers. We are hoping that most of these teachers will come to the April Work Shop ... then in April; we actually do the workshop in an effective way to help them with simple activities with basic concepts of magnetism and magnetization. In May ... may be give them a post test ... This is then the tentative structure. So far it has been four (Saira, Samina, R and Salima) of us working on it since we conceived it and that are directly involved. However, I think it would be very helpful if all of us are there (Group Session Charan March 2, 2001).

After I shared my thoughts with the participants, they expressed the following:

Nina: Yes ... we participate. We can be among the participants.
R: That is one way or could even be part of the facilitating team.
Nina: So we can get the ideas and experience. It will be new learning.
R: You do not have to decide now. Think about it and let me know in due course. (Group Session Charan, March 2, 2001).

Engaging in this workshop exercise was over and above the already ongoing commitments of the participants. Consequently, I had no intention of imposing this upon them. At the same time, I felt that I should share this idea with the group and leave it open to them to decide whether they could commit to it. At around this time, PT's and Saira's school system had brought in a new policy to switch the Friday and Saturday schedules effective April 1, 2001. Friday was originally a formal teaching day and Saturday was either a working day for the teachers or a day to attend professional development activities. Both PT and Saira were disappointed because this clashed with

the SAP Saturday Workshops which were held on every second Saturday of the month. PT was, thus, only able to contribute resources that she and I had developed for teaching the topic 'magnets.' Saira was able to make alternate arrangements for her lessons, but needed transportation lest she had problem reaching on time. Nina, who wished to be a participant-observer, also needed transportation. Taking into consideration our various concerns and wishes; we were all responsible for the workshop in different ways and to different extent. This was reflected in the conversations and journal entries of the group members.

Group Members' Reflections

When I mentioned to Salima that we might do a workshop she became excited. Her thoughts were on the same line as Samina. Her immediate response was, "We need it." She then went on to add:

> Just some days ago I was to teach sound and though I studied the resource packages, you remember the ones you sent to us from the English Language Resource Unit; I had difficulty in concepts like pitch. I read three to four more books, I still was not comfortable. I then discussed with Samina and then I taught the students.

We had a short discussion about this:

R: That you recognize your self what you know and what you do not and then take an action to comprehend the concepts yourself before you teach is very important step. You sure have the right approach. I am pleased to hear.

Sal: Mrs. Pardhan (R) it is very important ... After leaving IED I thought I know much ... when I started working with the teachers and as a teacher at my school again I realized that 'the more you know, the more you realize how less you know' ... and just remembered a saying 'those who think they know everything they know nothing.' (Personal Journal Entry Charan February 17, 2001)

> Today we (Saira, Samina, Salima, R, Nina) conducted workshop. ... I had short session ... warm up activities, magnetization and demagnetization. In the begining I felt very confused 'can I do my session confidently?' But when I started my session I felt I am doing my role comfortably and Charan did not interfere ... the workshop went very well. Every participant tried to get more knowledge about magnetism. (Journal Entry Saira April 14, 2001).

> ... for ... second part of this workshop (meaning May Workshop) ... as the new acting Head Mistress Primary Section I got extra responsibilities ... more activities like holiday home work, orientation meetings, teachers' meetings .... These things dishearten me 'how am I to do my responsibility?'... to do the workshop and Charan (R) gave me support ... from this workshop I learnt ... pre and proper planning of each thing makes it successful, trying out the activities

> enhance our own content knowledge, ... graduates also seem not to know in depth ... and also how they transform their knowledge to students. ... It is not only our students' fault but our adults also need some guidance. I think teaching is not an easy task. It needs our time and belief if you are really to do your job sincerely,which will give benefit to our students. Otherwise it is meaningless. Of course, some constraints and barriers come in our way 'if you are a good athlete you can overcome these.' How is your feeling? (Journal Entry Saira May 12, 2001)

> When Charan (R) asked me ... to work for the workshop ... I was happy and ready ... she is so systematic and organized that working with her is always a pleasure rather than a duty. Though I have never taught this topic yet I know that when I work with her I will be able to learn and get new ideas on this topic.
> Charan has been very kind and helpful in providing us with her own private car ... Otherwise it would have been very difficult ... I live very far ... and I am not used to going myself on any public transport and it (public transport) is even very difficult where I live.
> The workshop was ... well organized. As I had only a small role I got the opportunity to observe and talk to the workshop participants. Most of them were very interested and wanted to know a lot specially getting handouts and how low cost models were made. They enjoyed working with magnets of different shapes and how lines of force were arranged around them ... the participants were eager to know everything. Charan has a way of explaining things which really has long term effect and I heard many of them say ... 'If we had been taught like this then we would have had better concepts.' ... I have learnt many new interesting things like finding the Geographic North, how to make magnets, making magnetic lines using iron filings ... Many workshop participants were ready to sit for more time and know more therefore Charan said we will continue with the workshop next month. Most interesting thing is that attendance for the workshop was very good i.e. about forty participants which are never more than twenty in other workshops. (Journal Entry Nina April 16, 2001)

Workshops: A Possibility

> A workshop is a set of structured activities that provide opportunities for learning through thinking, practice and discussion. It is not a rambling seminar or an exploration of feelings – although discussions of feelings may occur (Brown and Wragg, 1993, p. 51)

Both of the workshops were perceived positively by the team as opportunities for professional development, particularly with respect to pedagogical content knowledge. They were also well-attended and well-received by the participants. The regular, insightful journal entries of the participants have helped me to support my perception and belief that workshops, if designed to address the needs of the participants, have the potential to benefit not only the facilitators, but also the participants. This was also supported by the high attendance, responses to the evaluation questions, informal comments of the teachers, and teachers asking for more time and more of such workshops:

> Time duration of workshop should be increased ... need weekly workshops ... have such sessions twice a month instead of once a month. (SAP Workshop participants' comment)

> Such type of workshops can help the teachers not only enhancing their content knowledge but to learn various ideas for effective teaching (SAP Workshop participant)

Chapter 7
MY LEARNINGS, FINAL REFLECTIONS, AND IMPLICATIONS

Meeting students' learning needs, as well as offering as much variety as possible in student learning experiences, were the salient goals of the research participants right from the very start of the project. Furthermore, their belief that this project had the potential to make science teaching and learning more interesting, meaningful and learning with understanding (Skemp, 1986) was a strong driving force for joining the project. Although these are not the only reasons (specific reasons have been discussed in the participants' stories and exploration chapter), they reflect a concern that students should be actively engaged in learning. The underlying assumption was to teach for comprehension, interest and purpose (Shulman, 1986; 1987). In classrooms where active learning occurs, high levels of dignity, energy, self-management, community and awareness are present (Harmin, 1994). Through the processes of collaborative action and research within a pedagogical content knowledge framework, the students of the research participants experienced a number of benefits. The participation in the project was highly valuable for the research participants who experienced teacher development at many levels. The insights and findings of this project come from three areas: a) the action research process b) teacher development, and c) pedagogical content knowledge in school science. However, the three cannot be kept apart and are for the most part interwoven.

My Learning Experiences

Though I had been involved in advising and supervising MEd students' research at the Aga Khan University Institute for Educational Development, Karachi, Pakistan, this was my first time to conduct formal research in the field of Teacher Education (although I had pursued a graduate program in science). Like any other beginner in a new undertaking I had experiences of both constraints and opportunities for learning. I will next address some of my major learnings in conducting this study.

Massive, Messy and Overwhelming

> A common and worrying problem for teacher-researchers is that they often gather so much data that they rapidly become overwhelmed by it all. (McNiff, 1988, p. 81)

During field work, not knowing what could ultimately turn out to be 'the data' for supporting arguments when writing my thesis, as a researcher I found myself collecting massive quantities of information with a belief 'to be attentive to intentional as well as unintentional actions to be able to get a broader and in depth insights of the situations' (Personal Journal Entry March 15, 2001). To start the process of interpreting the massive but rich descriptions became overwhelming and psychologically disturbing 'what to take and what to leave, where to start, how to start' were some of the questions hovering in my mind. Advice I often gave to my MEd students when they were in similar situation, I had to now give to myself. I said to myself, "No doubt it all looks 'messy,' but what would help is to ask myself searching questions to get a focus and keep documenting my thoughts." Writing in itself is action research and it is reflective and recursive. The process proved to be tedious and called for patience ("action research is not for the impatient" (Adelman, 1993, p.11)) and perseverance. It was no doubt 'desert experience' but, like oases in the deserts, there were green landscapes in the 'mess' that had to be located. What helped me to do this was to step back and revisit the purpose of my study and the related questions I had been asking or formulating to clarify my thoughts. For a researcher, it is essential to have a clear vision of what s/he wants to do and find thus clear questions to guide and write the study.

Mentoring Dilemma

In the process of mentoring, especially in the initial stages, at times I noticed myself being in a conflict ... wanting to offer 'advice' to have work done in anticipation to obtain 'concrete' data recorded and on the other hand to stimulate, encourage and motivate participants to venture into risk taking and discover issues themselves and internalize the process. I think there were two main reasons. The first being the influence of my strong science background and experience in a 'positivistic' approach to research. The other one being that I saw the latter as time consuming and hence painfully slow and I had a tendency to be impatient. Especially when many unexpected interruptions occurred.

However, constantly reflecting and reminding myself about the purpose and nature of my research, I learnt that I have to be patient, and let things evolve and record what I see and hear. Patience, perseverance and persistence helped me to maintain a clear vision and work with participants to allow them to take risks and learn.

Temptation to Digress from Research Agenda

Though I entered my research field work with theoretical knowledge, it certainly was not enough. The actual field experience of research was not simple and straight forward. Some times the data collection was complicated by participants' views and priorities at variance with my own. Though what they wanted me to do was genuine and of immediate need for them, if it did not directly fall within my research I had to make a genuine effort not to interfere with what I wanted to do. For example Nina's request from her head to do sessions for her school teachers to help them reconceptualize curriculum, and Saira's request to get involved with another research project with her head about parents' preferences for choosing their school for their child. This was challenging because the wish to stick to my research agenda and not entertain other requests had the potential to offend. However, alternate suggestions were considered jointly with the concerned participants as and when feasible. This the participants appreciated and accordingly they informed their heads.

Use of Language: Technical and non-Technical

Though my participants had been exposed to much of the current terminology of teaching, I still needed to exercise care while using research terms or phrases or even articulating my thoughts and ideas. I either described the technical word in familiar and simpler words after exploring participants' ideas e.g. action research (refer to pp. 83-84 Chapter 4) or from time to time, I used simpler language with the technical word to ensure that participants understood the concept. Like 'find out/look for details' for analysis, 'teaching/learning' for practice, 'think about' for reflect, and 'strategies/activities' for representations. This did not affect the research process; instead it helped the participants to understand the technical words. For example, Saira once commented "what Charan (R) calls representations I used to call 'activities, approaches,

models and analogies." In spite of this, it was found that sometimes words and statements seemed to convey different meanings to other participants. This was either because the word was not familiar or had different connotations. For example, on October 3, 2000 during a conversation with Saira, my using the word 'absolutely' surprised and suddenly quietened her. This alerted me and I needed to clarify it:

Saira: I will call you tomorrow at the same time like to day at 9:00 o'clock and tell you my principal's response about videoing the lesson.
R: Absolutely.
Saira: What? Sorry? What?
R: Absolutely (I repeated slowly and clearly).
Saira: (paused) *Achaa* (alright).
R: What I meant to say is 'it is fine.' 'It is okay.'
Saira: (laughed) Okay, I will call you.

The word 'problem' can be interpreted differently by teachers and it can become problematic. For example PT said, 'I have no problem ... all my problems were solved in Subject Specialist Teachers' (SST) Program.' I suspect in this situation the teacher might have interpreted it as '*koyee maslaa hai*' that is 'being incompetent' or 'not fit' to teach or herself being a problem. Culturally and by human nature, it is unacceptable to be considered as being a problem. This I think is the reason for PT to be somewhat defensive and say that 'all my problems were solved ...' ... 'I am satisfied with my practice.' An expectation of the SST Program (for which I was a coordinator and facilitator) was that the participants emerge as exemplary teachers. This I assume could have lead PT to say this so as not to displease or disappoint me. These were also the possible connotations that the head teacher attached to the word 'problem' when I approached her for permission to video a lesson as expressed in dialogue in Chapter 4 on page 68. Though the teacher's descriptions, like 'students make me angry' ... 'girls make noise' ... from my perspective of action research can be considered as problems. But I suppose the participant did not want to identify herself with the problems, and she was unaware that these are problematic areas that needed to be worked upon. I perceived the word 'problem' in terms of Elliott's (1991) view as anything that "impinges on one's field of action and is something one would like to change or improve on." This implies that it can be a new idea like a new strategy or approach a teacher might want to test to improve student learning and environment. However, I avoided this word as much as

possible and instead used 'concern' ... 'what did not work' ... 'what do you want to make better or improve?'

Self-Reflection; a Challenge

Though my participating teachers had been exposed to reflecting upon their practice during the Subject Specialist Teachers' Program, they still had some difficulty in reflecting. Participants' reflective ability improved through probing and challenging during joint reflections and group interactions, writing personal career stories and reflective journals, mirroring self through audio and video recording and organizing thoughts in a grid. I presume pressure from the need to fulfill other obligations and responsibilities could have been responsible for the participants' lack of awareness to self reflect. But I feel it was more than that because even when I was with them, they still had some difficulty until I probed and stimulated their thoughts. However, the participants became better with the passage of time.

I have come to realize that self reflection is a challenging task and teachers do need opportunities to be challenged and questioned to develop the skills and the habit. This has been recognized by other scholars too. Jaworski (1994, p. 201) comments that "reflection without some motivating, supporting, driving, external agent is very difficult to achieve ... ." She further goes on to say that "asking one's own searching questions is very much more difficult." Habermas (1974, p. 28) puts it this way:

> The self-reflection of a lone subject ... requires a quite paradoxical achievement: one part of the self must be split off from other part in such a manner that the subject can be in a position to render aid to itself ... (Furthermore) in the act of self-reflection the subject can deceive itself.

In order to critically reflect requires one to question one's beliefs and perceptions. This in turn requires one to detach 'one's self' from his or her 'real' self; that I believe is hard to do. Besides this challenge, initially the participants were not sure of what to reflect upon. This being their first experience to get involved in research, they lacked the skills to identify educational aspects upon which to reflect. Some other constraining factors were technical, pedagogical, institutional and personal. It was a struggle for the participants but they persevered and took risks to shift more towards making time for being more attentive to their students. They did try to make more space for students'

doing, talking and recording. Their pedagogical content knowledge also improved, "I learnt more and clarified my concepts on osmosis and diffusion by ... reading, sharing my difficulties and discussing ... I replanned and retaught the lesson ... students gave better responses" (Journal Entry Nina, December 9, 2000):

> reading extra information ... recording Moon cycle ... using models helped my understanding about phases of the Moon ... I learnt where Moon, Sun, Earth can be for each phase ... also students enjoyed and it helped them. (Informal post-lesson talk Saira, December 2, 2000).

> While they (students) were doing group work, I went around with a bucket of water and grape fruit to make students feel ... hands push downwards and the push of the water on the grape fruit ... the students enjoyed this activity ... students themselves gave the answer ... 'Miss water is pushing the grape fruit up ... this also helped to manage class discipline.' (Journal Entry PT, November 11, 2000).

Though these participants were committed and willing, they experienced a tension between what they believed to be good practice and what was expected by the institutional or system pressures, conformist tendencies and other contextual factors. Unexpected holidays, introduction of new policies at short notice, expectations to fulfill other obligations as required by their schools meant making alternate arrangements and adjustments to my sessions and visits. In cases like the month of *Ramadan*, some sessions had to be made short at participants' request. However, it is worth noting that these participants were involved in the research project on a volunteer basis. That is, no extra time was provided to them by their schools or concession given in terms of responsibilities to help them.

Though my participants were convinced of the need to use other teaching strategies to help their students learn better, factors like the examination system and the need to cover the syllabus were constraining their efforts to innovate and improve their pedagogical content knowledge through action research. Unfortunately, with the examinations dictating the practice and the need to 'cover' the syllabus, priority was given to the acquisition of knowledge rather than the process. This of course encourages a transmission mode of teaching.

Whatever I have said of the participants was also true about myself. I intended not to evaluate my participants. However, in this research situation it proved to be problematic for me to separate my familiar position as a teacher educator and 'evaluator of teaching' from my new position as action research facilitator. This evaluative stance is sometimes

reflected in the phrases or words used. Critically re-reading my descriptions I see phrases like: 'the discrepancy between her (PT's) conceptual understanding of the subject knowledge and the children's ideas still went unnoticed by her (PT)' (p. 71 above) ... 'Saira's special attribute' (p. 74 above) ... 'I had to impress upon PT the need to consider looking into the physical facilities and resources in terms of their appropriateness, availability, function, and organization' (p. 101 above). I was "confronted with the problem of the unconscious nature of ... own use of language" (Gadamer, 1975, p. 237). This reflection made me conscious of my own use of language, and showed, despite my intention to do otherwise I was still caught in a shade of bureaucratic and evaluative relationship with teachers. Despite our "wanting and doing" (Gadamer, 1989: cited in Jardine, 1997, p. 163) we still differed in our positioning, level of thinking, and expertise in science pedagogical content knowledge. These differing identities continued to be experienced as a tension in defining my roles and responsibilities.

Teachers Can do Action Research

It was found that teachers can engage in and do action research through 'systematic observation and reflection' (Lenzuen, 1994: cited in Palmieri, 1996, p. 6), if a conscious and deliberate effort is made to provide an opportunity and support to do so. Though the teachers with whom I worked were already overburdened by their teaching load and other personal and professional responsibilities, they participated in the research with willingness, interest and commitment.

For example, in spite of unexpected interruptions at short notice that required the participants to make new adjustments, they (participants) preferred to carry on with project classroom visits and group sessions. They were the ones to suggest the use of telephone as a tool to communicate effectively and practically. The use of telephone in this way is not a cultural practice in Pakistan, "teachers only communicate at school ... do not do this (communicating by phone) ... In fact talking ... mainly social ... is done mainly when people meet at gatherings" (Phone Conversation Workshop Planning, Salima, April 4, 2001). The participants were prepared to risk it to achieve their goals.

Writing personal stories about teaching as a career, making grids over and above journal writing, all these thought provoking and time consuming exercises are concrete

evidence of participants' willingness. For viewing videos and listening to audio tapes in the evenings or weekends, the participants had to make special arrangements, hence extra time for resources; 'today I have Saturday off which I am spending at my sister's house to use her cassette player to listen to my audio recorded lesson' (Journal Entry Saira October 14, 2000) ... 'After listening to the tape at home, I felt I did not miss anything of the group session of December 1, 2000 ... I had got all the handouts of the cycles ... but when I listened to the tape these handouts became more clear to me' (Journal Entry Saira December 6, 2000) ... 'viewing of the video at home was very helpful for writing my reflection and getting a total picture of what was happening in the classroom ... (Journal Entry Nina October 6, 2000) ... 'Today before group session I was listening to the audio tape ... the students used to be silent while listening but make a noise when they are asked a one word answer question ... questions need to be framed in such a way that it makes students think and not to give the answer in chorus' (Journal Entry PT November 10, 2000). PT, though required by family responsibilities to be home immediately after school, made extra time before group sessions to listen to or view her lessons recorded on tapes. Although I was taking much of their free time (non contact time) because no extra time was provided for the project, they were willing to spend more time for various reasons as the above interactions and descriptions suggest.

Teachers Can Successfully Carry On Action Research

In spite of the hurdles, this study had many positive outcomes for all involved in it, particularly the participating teachers, their students, and me. This I credit to the participating teachers for their willingness, commitment and openness to take ownership and to carry on the action research process successfully. Action research, if collaborative and characterized by self-critical communities of practitioners (Carr & Kemmis, 1986), can provide teachers with a voice in curricular decision making, can foster personal and professional growth, bridge the theory-practice gap, and enhance the teachers' reflective practice. The process of action research helped to achieve these goals; however, each participant's experience remained unique. No doubt, there were challenges and frustrations, but these served as ongoing stimuli for individual or group reflections and discussions. These reflections and discussions focused on the pedagogical content

knowledge through the action research process and its importance for science teaching and learning, science teacher development, and curriculum development.

The participants came aboard the project with cursory understanding of action research and diversity of background, beliefs and classroom practice. Considerable time was spent at the initial stages in exploring and comprehending salient features of action research, identifying participating teachers' needs, and collaborative strategic planning and preparation. This process was necessary to meet the needs to realize positive outcomes and to have the participants take ownership of the research problem and the process. This I believe is one of the main reasons for the success of this project. The action research process was predominantely at the practical level with an aim to move into an emancipatory level by deepening critical social reflection (Carr & Kemmis, 1986). The participants made time and put in genuine effort to achieve their personal goals. This resulted in the establishment of a support network early in the action research process. A support network was an integral part of the action research process, achieved through individual weekly and monthly group sessions. In this study, it became an avenue for sharing and exploration of ideas and feelings, curriculum resources, offering feedback, and providing moral support in a safe and an approachable environment. These opportunities for collaboration, combined with participants' motivation, were greatly responsible for the participants' professional development and achievements. As far as the teachers' action research is concerned, some of the specific positive outcomes of this process were:

- Reflection was the dominant feature of the action research process. Through different avenues like reflective journal writing, grid making and group discussions, participants' thinking became explicit.
- All participants became more attentive and critical about their practice and as a result improved their practice in many ways.
- All participants became more aware of their strengths and weaknesses and how these affected their teaching. They also became more confident and competent with teaching of science and voicing their thoughts.
- The participants increased their pedagogical content knowledge by trying out innovative ideas and modifying their lesson plans and units. They became more

attentive to their students' interests, needs, difficulties, and responses. Thus they were able to identify students' alternate frameworks and planned lessons to accommodate these. Overall they became significantly more student-oriented.

- The participants became curriculum developers. They made decisions about curriculum expectations, designed meaningful learning activities to motivate the students, implemented curriculum, and assessed it and modified it. They also created science unit plans in which connections were made to other disciplines or topics. This helped students to think of science more broadly, thus to foster positive attitudes towards science.
- The participants enhanced their conceptual understanding in science through the framework of pedagogical content knowledge. This in turn impacted their teaching, and subsequently student understanding of science concepts.

By engaging in the process of action research and enhancing their pedagogical content knowledge the participants became more student-oriented and were able to make the learning of science more meaningful, interesting, relevant, and personalized for the students. Such a process has implications for pre- and in-service teacher development programs while developing the structure of professional development.

What Motivated the Participants?

Participating teachers' enthusiasm to get involved in the research project and to make extra time for the evolving activities was due to a number of things. One of these was that the study was geared to and co-opted into what the teachers were already doing. Their syllabus or scheme of work was strictly followed, coplanning and teaching and discussions were centered on what was going on in their lessons and what was feasible. This made the research project authentic because it was addressing their real concerns:

> These cycles make our teaching more meaningful and interesting in science ... that whatever problem or concern we faced during the lesson, we analyzed then we followed the cycle ... planning, implementing, observations, reflecting, sharing and getting feedback, and replanning ... These cycles make our teaching more effective. (Journal Entry Saira December 6, 2000)

The other reason was that participants were free to speak and act for the most part under the influence of their own experiences and knowledge. Mostly it was they who

decided what to do and how to do it. They made judgments about the concepts of 'right' and 'wrong' themselves, on the basis of their own perceptions even though they were provided (by R) with the 'Expert' knowledge to encourage, support and facilitate their decision making process.

There were times when the participants' decisions were at variance with my perceptions of what I believed to be more appropriate. But I had to tactfully and carefully cope with it. For example during the very first post-lesson talk, PT commented in her Grid 'Ms Charan asked me to make a video of the lesson tomorrow. She did not give me any comments' (September 26, 2000). It was a hard decision to make, but it was what I felt most desirable to do. This was to help PT to judge for herself that a lesson that she said she was satisfied with did need improvement. I had to use a strategy to accomplish this. By commenting on the lesson I thought I would be doing her disservice. As a result PT, after watching the video, did take an independent decision; 'I have to improve in classroom management, lowering noise level and questioning skills' (September 27, 2000). In case of Nina and Saira as well, I refrained from giving my comments straight away. After their initial independent decision, I probed to elicit some of the aspects missed out and I perceived this to be helpful. This then made it easier to help them to reflect and understand their decisions in terms of their meanings, implications and suitability in a collaborative effort.

During the delivery of co-taught lessons or being in the class as a participant observer, I took some on-the-spot decisions. I was compelled to do so because I felt it was an opportunity to demonstrate an alternative in a real situation. These were also acts of intervention and they did worry me in terms of teacher integrity. However, participants comments 'Charan I am glad that you asked students questions or explained' ... 'I liked it' and their reflections helped to ease this tension.

Possibilities for Collaborative Teacher Development

Bell (1993) describes three levels of teacher development; namely, professional, personal and social. Professional development entails ideas and practice. Personal development is about teachers' feelings of being teachers and their perspective of the change process. Social development involves teachers developing new ways of working

with their colleagues or other teachers. As can be concluded from the above anecdotes and the discussions in earlier chapters (particularly chapters five and six), all three teachers involved in this project experienced significant development in each one of the three levels to varying degrees. What contributed to this? Not the individualistic culture of teachers that exists in most schools that leads to teacher isolation, but the collaborative efforts. This was even recognized by the participants themselves as their descriptions and expressions suggest: "At schools most teachers are busy with their own teaching and preparation" ... "I liked this sharing session" ... "I do miss discussing with other persons, being in the project I can now discuss ... it helps understanding a lot" ... "Sharing always helps in lessening the pain." Implicit in this is the participants expressing their need for a community.

I argue for collaboration and collegiality of teachers for teacher development as opposed to an individualistic culture. However, I suspect teachers do not always perceive teacher isolation as a constraint on their personal growth. Cochran-Smith and Lytle (1992) point out that some teachers take it as a blessing in disguise because it gives them privacy and autonomy. The culture of collaboration and collegiality of teachers is perceived by many as having the potential for interference with their functional autonomy. For example PT's co-teacher stopped coming to classes after our first co-taught lesson. PT explained that this was due to the co-teacher having other things to do, like copy correction and making reports. PT also added that perhaps if she were in her place she would do the same. This, I believe, is the legacy of the colonial heritage of Pakistan's educational system that works on a bureaucatic, top-down approach. In this system, the government has direct control of schooling, hence, the teachers' autonomy and empowerment is constrained. As a result, there is very little hope for classroom-based innovations. The teachers' participation in efforts to improve the quality of classroom teaching and learning and curriculum development is impeded.

To counter this, teacher education institutes like the Aga Khan University Institute for Educational Development, Karachi, Pakistan have taken up a humanistic approach to teacher education. Teachers are perceived as intellectual and autonomous beings capable of making decisions about their classroom practices and themselves. Furthermore, the approach encourages schools, teachers, and tertiary institutions to engage in collaborative

action research for school-based problem solving and reform. The intent is to empower teachers with a vision to bring about an educational change over a period of time. This action research project is an example of these collaborative efforts.

I have come to believe that teachers should become researchers in their own classrooms and contribute to their self development and school improvement. Teachers investigating what goes on in their classrooms have always been (and will be) in an intitutive or a subjective way a feature of educational practice. This is where the concept of action research ties in. Today action research is coined with a number of activities in professional development, school improvement programs, and curriculum development. The common features to all these is strategically planned activities that are implemented and then subjected to observation, reflection/evaluation, and change. In this process the participants are integrally involved in all the activities to the action under consideration. I contend that change can only occur through this cyclic process of observations, reflections, and action. Gurney (1990: cited in Palmieri, p. 3) has eloquently described this as, "action research is a quality means of encouraging change – one that shows respect for practitioners' control of their own practice and learners' control of their own learning." This is what I have come to realize was greatly responsible for the success of our project.

In our project, the participants' beginning practice was predominantly a traditional transmission mode of teaching. The teachers' descriptions reveal how their school culture and educational system at large perpetuate a discourse of traditional teaching. Change in their practice began when they took part in the in-service teacher development programs at the Aga Khan University Institute for Educational Development, Karachi, Pakistan. These programs employ constructivist and reflective practice approaches to teacher development. All three participants acknowledged that the programs had greatly influenced their taken-for-granted practice. Furthermore, the programs provided them with approaches and strategies to make their science teaching more participatory, meaningful, and relevant to the lives of their students. The participants' implementation of new learnings indicated their perception of teaching as an individual activity where the teacher has the autonomy of making decisions about pedagogy and curriculum. Their descriptions also indicated their belief of teaching as a dynamic process that demands

active inquiry into their own practice. In spite of a change in their practice, at the beginning of the project, the participants still saw teaching and teacher development as individual activities rather than social ones.

However, reflecting upon the participants' descriptions and my own personal experiences of having taught the in-service programs has made me realize that social, cultural, and institutional imperatives that could constrain the implementation of their learnings were inadequately addressed. As a result, concurrent to struggling with their pedagogical content knowledge, the teachers had to struggle to change the structure and beliefs in the school and society that offered the resistance to their efforts. The extent of the struggle varied according to the working environment of the participants, since "the contexts in which teachers work are believed to affect what they can do" (Wilson & Berne, 1999, p.175). Saira had more administrative and peer support compared to Nina. Her school also demonstrated a stronger sense of community. This supported Saira's growth compared to Nina who was struggling in isolation. However, engaging in the process of action research, the participants became integral members of a community of "fellow learners and researchers." This enabled the participants to "struggle along with others to construct meaningful local knowledge and where inquiry is regarded as part of the larger efforts to transform teaching, learning, and schooling" (Cochran-Smith & Lytle, 1999, p.278) in a supportive and encouraging environment. Another significant development of our action research efforts was the formation of a primary and secondary science teachers learning community at Saira's school. This in turn lead to our networking with other Karachi science teachers outside Saira's school boundaries in collaboration with the Science Association for Pakistan. I have every reason to believe that my action research group members will continue their efforts and commitment for their own and fellow teachers pedagogical content knowledge growth even though the project has formally ended. As evidence, I have recently received emails from Saira to update me with new developments of her group. An example she shared is that they are exploring the use and integration of technology in the teaching of science.

I am in favour of promoting communities of science teachers and networking as alternate approaches to science teacher development of pedagogical content knowledge. I have realized that these can provide teachers with opportunities for agency, reflection,

collaboration, and membership in the community that are crucial for change in their practice and eventually in the system. Communities allow members with different pedagogical content knowledge expertise and backgrounds to interact in increasingly differentiated ways and construct as well as reconstruct their pedagogical content knowledge socially. It undoubtedly takes time and effort to establish a sense of community, but once it has happened teachers are more likely to share their successes and failures willingly and openly with pedagogy and curriculum development. Moreover, they are more likely to review student work collaboratively and constructively. In the process the members develop shared language and perspectives about pedagogical content knowledge. This is what constitutes to me a learning community. A learning community is a powerful means to foster a collaborative culture amongst teachers and to move away from a culture of classroom isolation to improve the quality of teaching and learning, in general, and of science, in particular. My underlying assumptions are that members engage in rigorous discussions and evaluation in a supportive and non-evaluative environment and that they exercise flexibility, thoughtfulness, and care over a period of time. Collaborative action research with school heads' support paved the path for our project to form a community of learners.

In my action research study, the school heads and administration showed interest in the teachers working together. Dean's (2000) study, carried out in Pakistan, also documents support for action research by the administrators. The Institute for Educational Development which encouraged and supported these two studies, is in the process of developing action research with the schools and the in-service teachers (Dean, 2000; Kanu, 1997). Initiatives are in place both in the urban and rural areas. Thus there exist possibilities to promote and sustain communities of learners, especially amongst science teachers. This can be done through dialoguing and negotiating with the school heads and administrators desired conditions, time, mental space as well as support for the teachers to enable them to work in communities to develop their pedagogical content knowledge growth.

Action research projects may or may not involve university researchers like myself. In the case where university researchers are involved, I recommend that they be engaged in second-order inquiry to reflect on their roles and responsibilities as researchers/

facilitators and that they assess the effectiveness of the action research process. This is to ascertain the merits and nature of action research. However, action research in either case can facilitate teachers' professional growth and encourage them to voice their feelings and thinking.

I have come to appreciate that action research, in which teachers document and analyze their own direct classroom experiences individually and collectively, allows for them to talk about subject matter, about students and learning, and about teaching. That is teachers working together to reflect upon their practice to learn how to enhance their knowledge categories that are necessary for generating Shulman's (1986, 1987) pedagogical content knowledge. Cochran-Smith & Lytle (1999, p.262) have conceptualized this knowledge as "knowledge-in-practice" that teachers acquire "through experience and through considered and deliberative reflection about or inquiry into experience." This is consistent with the process and expectations of action research. Action research is an important avenue for teachers to improve their teaching and curriculum. I concur with Noffke's (1997) belief that what teachers learn through the action research process can be shared with others. Learning communities to me are appropriate sites/contexts for teacher sharing and learning. This can help to sustain teacher learning through teachers teaching other teachers by encouraging and supporting their intellectual and pedagogical growth. However, lack of time, resources, and differences between teacher/practitioner research and academic research can act as limitations to the use of action research as a way of sustained teacher learning. I contend that if action research is collaboratively conducted amongst teachers to foster learning communities, committed and willing teachers will strive to sustain on-going learning.

Future Research Possibilities

As a university researcher and facilitator, I hope to continue to be involved in school-based action research to link theory and practice. I want to encourage teachers in the Aga Khan University Institute for Educational Development's collaborating schools to become more self-directed, critical inquirers into their own practice, and form network groups to affect their colleagues. This could involve exploring a) salient aspects of science teaching and learning related to pedagogical content knowledge. Some specific

ones being authentic assessment, problem-based learning, and curricular saliency b) how in-service and experienced teachers from less privileged schools develop their knowledge-base for the teaching and learning of science. I also want to encourage institutions to plan supportive structures for teacher dialogue so that this concept of teacher growth can be supported and sustained.

I would like to pursue a follow-up study with my research participants to know if the knowledge they acquired from their involvement in the project continues to shape their present and future practice. This would allow me to encourage the participants to be mentors for their colleagues and carry on their own school-based research to form communities of learners and friends to collaboratively support and stimulate personal and professional development at the school-level. They can then reach and impact more teachers through the organisations like the Science Association for Pakistan by sharing their experiences through avenues of workshops, publishing their learnings in the Science Association for Pakistan's newsletter or other journals, and making their curricular materials accessible to teachers in general.

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Appendix A

In-service teacher letter of invitation

Dear _____

The purpose of this letter is to invite you to participate in a research study about reflective dialogues and narratives. I am investigating how to enhance the pedagogical content knowledge of teachers in Pakistan. I, a science faculty member at the Institute for Educational Development (IED), Karachi, Pakistan, am currently a graduate student in the Department of Secondary Education at the University of Alberta, Canada, with an interest in in-service teacher development, focusing specifically on science teachers. As my research question requires me to investigate and work collaboratively with teachers I have chosen to work in an action research approach to my study.

Action Research is a process of inquiry that treats each participant equitably, values the involvement of all its participants with a hope that the lived experience as a participant in the collaborative group will promote professional practice of those who choose to participate. It is anticipated that this professional and personal growth will manifest itself in constructive social action that will occur as discoveries unfold within the group.

To complete this study I require a group of 3-4 teachers from the cohort of 1997/98 one-year Advanced Diploma graduates, who are within close proximity of IED and teaching classes 1-8, for the period Sept. 2000-April 2001, and willing to make time commitment over and above their normal working hours.

Your involvement in the study is voluntary. If you choose to participate, you will be:

1) Asked to attend a debriefing meeting about the nature, purpose and expectations of your involvement in my study, in April 2000 at IED (during my short visit).
2) Required to collaborate with the group in the process of inquiry during the period Sept. 2000-April 2001 to generate information through multiple methods of data collection, including:

- Conversations/interviews (individual and semi-structured, if necessary).
- Classroom observations of your science lessons.
- Examination of personal document (personal reflective journal), field notes, lesson plans, student's written work.

I have no set agenda for the period Sept. 2000-April 2001 in terms of topics, themes or times, venues for observations, interviews, and conversations. This research may involve classroom observations once per week per participant with a pre and post conversation/interview (15-30 min each) and a group session (about 1 hour) once every two weeks. This and any other emerging needs for meetings are open to negotiations and will be scheduled at mutually agreeable times. It is hoped that these sessions will be of benefit to all participants; therefore, the frequency of these events will be revisited at appropriate times before and during the course of the fieldwork.

With your permission the interviews and conversations will be audiotaped, and transcriptions will be shared and accessible to all participants; the purpose of the audiotape and transcript is to fully include your ideas for later data analysis and group validation.

Throughout the research, the use of fictitious names will protect your identity and that of the school. All responses, comments, dialogues, field notes, and artifacts will be confidential until published in a dissertation. Beside myself, only my university supervisors will have direct access to the raw data. If at any time during the research you wish to withdraw you may do so simply by letting me know. At that time, your data will be withdrawn from the project. The research in its completed form will be compiled into a thesis that is open to the public. After this point all raw data will be destroyed.

If you feel comfortable with the process, please complete the attached consent form and return by _____. Any questions regarding the purpose of the study or your involvement in the project can be directed to me electronically through e-mail at hpardhan@hotmail.com for the month of March and period May-August 2000; for April and field work period Sept. 2000-April 2001 through telephone (IED) number 634-7611/2,3,4. The other contact in case you wish to discuss this study and your involvement further is: Dr. D. Blades, Research Supervisor; Department of Secondary Education; University of Alberta: telephone 780-492-5415 or email david.blades@ualberta.ca.

Thank you for considering my request.

Sincerely,

Harcharan Pardhan
Doctoral Student

Appendix B

Voluntary involvement consent form

I_____ have read the letter by Harcharan Pardhan, dated _____, requesting my participation in the research study about reflective dialogues and narratives to investigate how to enhance the pedagogical content knowledge of teachers in Pakistan. I agree to participate with the understanding that:

a) I may withdraw from the research at any time without penalty.
b) I may request that all or some of the data collected be omitted at my request.
c) My identity and the identity of the school will not be revealed.
d) All information gathered (including audio recording and transcripts) will be treated confidentially and shared/discussed only with concerned participants and your supervisors, until publication of research results.
e) The results of this research will be used only in the following:
    - research thesis
    - presentations and written articles to other educators
f) On completion of the project all raw data will be destroyed.
g) It will not influence evaluation

Signature _____ Date _____

Appendix C

A mutual agreement: Participant

As a development of our discussion in our second group session we mutually agreed to video a lesson to enable us to better reflect on the science content. The video will remain safely stored with Mrs. Pardhan (the researcher) and viewed only by the two of us unless otherwise agreed.

	Reasearcher	Participating Teacher
Signature	_____	_____
Date	_____	_____
Place	_____	_____

Appendix D

A mutual agreement: Head

The Head Teacher
Name of school:
Karachi.

Dear Sir/Madam,

As you may be aware, I am currently involved in my doctoral studies at the University of Alberta, Canada. Having completed my course work, I am currently doing field work in Karachi as part of my dissertation process. I am doing a group project in which one of your teachers is a collaborator. This involves amongst other things, classroom observations and teacher reflection. For the purpose of teacher reflection I feel it is important that we video record a 'parallel' lesson to the one which I observed. This I feel will help the teacher to identify areas she needs to address to further improve her teaching. For this I am seeking your permission. I have already discussed this with the concerned teacher who is willing to be videoed. I would appreciate it if you can also grant the permission. The video will be kept by me and viewed only by the concerned teacher and myself. Should I need to show it in the project group I will seek the teacher's permission.

I hope you will grant me permission.

Yours sincerely,

Harcharan Pardhan

I have no objection for video recording the lesson

_____	_____	_____
Signature	Date	Place

Appendix 1

Group Session # 1, 15/9/2000: Summary of Participants' Ideas

Q #	Question	Nina	Saira	PT	Key ideas / themes
1.	How will I benefit from this project? What appeals to me? [the responses are somewhat influenced by participants April orietation and readings e.g. Project Overview... I think that is fine.]	Sharing my lessons with R [Researcher]. How I can improve from feedback and apply that to my students. It is a way of learning together.	I have same to say as Shaheen. It is new for me to involve in research and I *wonder* what we are going to do. Secondly I want to improve my personal growth and know how I can reflect myself. It will affect my teaching... become more affective. I read research has phases... planning, action, observation and reflection ... Observing (third phase) can benefit our students... " How can we observe the students and then how can we reflect on teaching" ... comes to my mind. In a small group we can learn more in a better way than in large group.	Would like to know more about action research and how it can be carried out, so I can learn it and it will help me to improve my own teaching. We can learn from each other by sharing ideas.	Learning is long-life!! Reflecting on Practice How do teachers learn? Self-reflection, working with others in small groups,sharing lessons/ideas and getting feedback, observing e.g. students, action research
2.	If I [R] were to visit your science lesson what would I see a.) You doing?	Giving some demos, some social work, sometimes experimenting with students.	Things like what Nina said... when you [R] come to my class I would like you to observe me and my students doing different activities and different focus targets I want you to observe from your side. I facilitate students by taking rounds... whenever they [students] feel any difficulty or they are stuck I facilitate them ... I give them different responsibilities.	As I teach class II so mostly I give demonstrations and then I give them [students] paper to write down what they have observed or what they have learnt... so either they are doing in group discussion or they are writing on a piece of paper.	a) demonstrating; facilitating social skills during group work; circulating/facilitating students work when stuck; if large class mostly giving demos (PT) Science learning is by doing/observing/interacting/communicating in small groups or/and whole class
	b) Your students doing?	Students are experimenting	Doing different activities... observing writing conclusion as a result in their notebook.	Observe teacher's demo and write what they have observed and learnt... doing group discussion.	b) doing different activities regarding the topic: observing; recording; experimenting; writing conclusions; discussing in a group

			Sometimes I give demo and after observing the demo... students also record observations.		or whole class or writing what students have learnt
3.	What would I see you doing outside class in your school as a.) a science teacher? b.) A teacher (not made explicit by the participants) [sort of a shocker... or intimedater .... participants silent ... looked at each other... exchanged smiles ... shrugged shoulders ... finally Np broke the silence with her response]	Most probably correcting the copies and doing correction work of students, sometimes planning, or choosing activities for the lessons to give... sometimes choosing reading materials relevant to lesson or topic that they [students] are going to do.	If I am in my science room you will observe me as science teacher... giving lessons to my students. Sometimes there is no teaching period you can find me managing or preparing different materials for the next class (lesson) because I have science lab and in this lab when students come for science lesson they will do practical...so I worry about materials I would like to set-up different materials for different groups... and so students can find everything ready when they come.	In our school there is co-teaching and so either I am teaching in my class it is all... when I ... never get a free time... I am either teaching or I am with other teacher as a co-teacher... so all the four periods I have I am in class so I do not get anytime... any non-teaching period.	Mostly correcting copies (all three); sometimes planning/researching resources/preparing lab before students come(two); never get free time.... am either teaching or co-teaching (one ... PT) <u>Non-teaching time availability and use</u>
4.	It is generally felt that there is a relationship between what teachers know and how they teach what do you think? *[For this had to probe rather prompt quite a lot]* [participants found this question difficult to understand: *question samaaj main nahin aaa ... rahaa* (question is not being understood). This matched with IED director's comment. Q 2-6: I had shared with my IED director in an informal intreaction. At that time I had this question at the top. My director's comment, " this is diffult as a starter" ... I realized and changed it to this number.]	Main thing is She [teacher] must know own content. Recognizing the usefulness of content that matters and then to apply in everyday life. For instant if we are talking or teaching about food... whatever foods are taken by small children to understand various nutrients and how they are helping them... for higher level we can do the testing of these foods. Encouraging the students, effective communication, learning is to be effective, if it is science class safe practice, promote awareness in students for working in co-operative groups.	I think teacher knows everything... but it is not necessary that teacher should give all instructions... but should give according to students' "mental level". If I am teaching in class four I must know what students know from class three and what they will learn in class five... so coordination is important... how they do previous and what they teach next to develop science skills in students; we cannot develop all skills at the same time... but we have organized planner... to develop three skills every quarterly.	She [teacher] must have clear concept. She must know how to make student's understand better. Age, level of students must be kept in mind. Teacher must teach in simple way and with simple words so they [students] can understand *R: asked for an example* Now we are teaching matter and we have to give them the concept of mass. At this age [class II]... I am going to use the word mass it will be useless. So we have taken boiled egg and we show them whatever we eat... the stuff which is inside it, the material which is inside....anything in the inside... I mean we have related that material with the mass. Although we have not used this word but we have tried to make them understand that has mass and occupies space... which is the definition of matter.	Know the content/concepts; know students mental level/age level and teach accordingly; know what students know from previous class and what they are to learn in the next class; teach in simple way and with simple words; know how to make students understand better; teacher should be encouraging, effective communicator, model safe practice in science class, all science skills cannot be developed at once but select skills at a time in a planned and organized way; promote awareness to work co-operatively <u>Participants' perspective about a teacher's knowledge base</u>

5	How do you think children learn? [Director's comment to this one was, "Is a shocker ... I had asked this question to a group of preservice teachers once ... there was pause, silence and I could say it shocked them". When later I shared with my director that my participants had spontaneous and sensible responses, he responded, " this was some years ago". My response, " This question did not shock my participants. They obviously have knowledge about it.. It is no surprise because they have had IED exposure ... VT and SST program. Also it is now not then ".]	From understanding the situations or questions created for the concepts to be learnt. From environment they pick up things for example mass and weight they meet things in such a manner that they know this is mass and this is weight. Differentiating them ... distinguishing them.	Through variety of assessment e.g. worksheets. By solving problems... problems mean scientific activity we give them, but in different situation.	*[Spontaneous ...and was the first one to respond unlike all previous questions and the others pitched in]* They learn by doing... want to understand something so we provide activities so while doing those activities they learn better than teacher is going to give them lecture. By observing, by doing themselves... practicing.	From situation or questions created for the concepts to be learnt; pick-up things from the environment and comparing and contrasting; solving problems from scientific activity given to them in different situation; by doing...themselves through activity;practicing ... learn by discovery teachers role not made explicit Learning by doing/discovering from the activities/situation/environment and practicing
6.	As teachers or teacher educators, what is our purpose of teaching science to our children? [very limited and away from the question responses.]	Same idea as Saira	We can start research on some focus or target problem	*[once again 1st one to answer and immediately]* sharing our experiences	Researching and sharing
7.	What concerns us to be able to teach science effectively?	• Content knowledge, new methods. • Making students aware of their environment using scientific methods. • Students can go beyond learning or doing in class but they can practice.	• Improve science practice.. Improve science learning of students... How students can develop different skills. • How can we make them [students] good problem – solvers... critical thinkers.	*[waited until all others had answered]* They [students] can apply ... application	'What' expressed but not 'How'? Purpose of science teaching is for science content, scientific method, skills, application and awareness of environment

Appendix 2

PT's lesson transcript for latter half lesson on 26/9/2000

PT comes to table #4 just near where I [R] am sitting— girls pick-up items and paper is provided by the teacher to the students(to write on (students get up trying to reach teacher or stretch out for items close to PT…)

Teacher what could this be? Teacher what could this be?	ٹیچر یہ کیا ہوگا۔ ٹیچر یہ کیا؟	SS
And this?	اور یہ	
(Holding one Students writing paper)		PT
Make a column for date	Date کا کولم بنؤ	
(Students continuing to say)		
Teacher what is this?	ٹیچر یہ کیا ہوگا	
Make column for date	Date کا کولم بنؤ (Again)	PT
Teacher what is this? Teacher this one has written here Coca cola	ٹیچر یہ کیا ہے۔ ٹیچر اس نے یہ کوکا کولا لکھا	S
Coca Cola	کوکا کولا (Picking up pop can)	PT
Coca Cola… in 'Coca Cola' there is 'K' sound… what other sound is	(Says twice Stressing ک sound) کوکا کولا میں کی کی آواز آرہی ہے۔ اور کسی کی آواز آرہی ہے۔	
'L' sound… teacher this 'Coca Cola' have to write… have not to write a lie but truth	ل کی…… ٹیچر یہ کوکا کولا لکھنا ہے، جھوٹ نہیں لکھنا سچ لکھنا چاہئے	S1
Not to write a lie… what is on it that is to be written	جھوٹ نہیں لکھنا ہے جو اس پر دیے لکھنا ہے۔	PT
Teacher what is this	ٹیچر یہ کیا ہے (I had placed recorder on this table, pointing at it)	S2
	آپ اس کو نہیں چھوئیں گی آپ کی چیز نہیں ہے اس کو نہیں چھونہ یہ آپ کی چیز نہیں ہے یہ آپ کی چیز نہیں ہے ٹھیک ہے	PT
	ٹیچر اس کو دیکھ (Looking at items) کے لکھنا ہے۔	S1
Teacher have to look at it and write		
Yes look at and write whatever things are… look at… and write… okay	ہاں دیکھ کے لکھنا ہے جو جو چیزیں ہیں ان کو دیکھ کے لکھنا ہے ٹھیک ہے	PT
You are not to touch it. It is not your thing. Don't touch it. It is not your thing. This is not your thing… okay		

Student puts forward to the teacher her paper with couple of lines and some writing… T stretches left hand and holds edge of paper.

What is this writing... child... what is this writing... hunn (pointing at a student's work sheet) یہ کیا لکھا ہے بچہ.... یہ کیا لکھا ہے.... ہوں PT

(Students together trying to say something seems like co ... coca ... teacher)

What is this writing کیا لکھا ہوا ہے PT

Coca Cola کوکا کولا S2

This one write Coca Cola... what is this you have written یہ کوکا کولا لکھے.... یہ آپ نے کیا لکھا ہے PT

This writting here is..name یہ اس کا نام لکھا ہوا ہے S3

Read پڑھیے PT

Ko... kaa... ko... ka کو.....کا.....کو.....کو S3

Teacher should it come up... ٹیچر یہ اوپر آئے گا S2

Why will it comeup? یہ اوپر کیوں آئے گا PT

(Students Vorces sort of mixed ..) کو.....کا.....ٹیچر.....کو.....ٹیچر اوپر SS

Ko... ka... teacher... ko... teacher up

Why would it come-up اوپر کیوں آئے گا PT

Teacher it has air... air is in it (and laughter) ٹیچر اس میں ہوا..... ہوا ہوتی ہوتی ہے S1

What comes in it? اس کے اندر کیا ہوتا ہے PT

Liquid comes in it (.....Liguid) ہوتی ہے Haan S1

Haan PT

Haan ... Solid ... teachers Solid S2

Solid PT

Gee – ram... جی رام..... S1

ہاں گرام میں آئے گا دوری کھودو PT

(Pleased repeats) gram ... gram S1

In gram گرام میں

(S2 starts almost singing coca-cola... coca-cola... and another student murmurs a tune... gram haan gram ...in a happy mood...liquid ... main aaay gaa... no sound of PT but students voices as working in groups... ooyay... ooyay... ooyay oo... yay... then one student calls the teacher:

Appendix 3

PT's own description of lessons dated September 26-27, 2000

Today's lesson
Materials have mass
I started the lesson with revising previous lessons and asked the following questions:
What is matter?
Students didn't respond.
Then I asked them again, but I told them "anything which has mass and occupies space is called matter".
Then I asked "How many states of matter are there?"
The answer was "there are three states of matter; Solid, Liquid and Gas"
Then I asked them
When you go to buy something (apples) what do you say?
(Key: S1, S2... Represent individual student and I represents the teacher i.e. PT)

S1: Give me answer 10 apples.
I: Can we ask for 10 apples?
S2: Please give me 1 Kilo apples.
I: Yes we ask for 1 Kilo apples.
What when you go to buy milk?
S1: I Kilo milk.
I: Can we buy 1 Kilo milk?
S2: No... 1 litre milk

Then I explained that things which are solid are measured in Kilograms, grams or milligrams but liquids are measured in litre, milliliter.
Then I gave them instruction "you have to make two columns write in one Kilogram / gram and in the other litre / milliliter. Now I'll give you some wrappers and cans. You have to sort out which of these things are measured in Kg or g and which in L or ml and write them under correct headings. At the end I asked what they had written from each group for kg/g and then for L or ml. With this I ended the lesson.

Reflection:
It is not easy to keep in mind all the things that children said and it is very difficult to do it immediately. It takes time to recap all the events. But I have written what I've remembered from today's lesson. Regarding video recording lesson, I am not sure how the children will take it. Most probably they will not be active; I am not sure about it. Let us see what happens tomorrow.
There are questions that are bothering me.
- How will the confidentiality of video be kept?
- Will it be shown to other teachers?

27/9/2000: Videotaped Lesson
Materials have mass

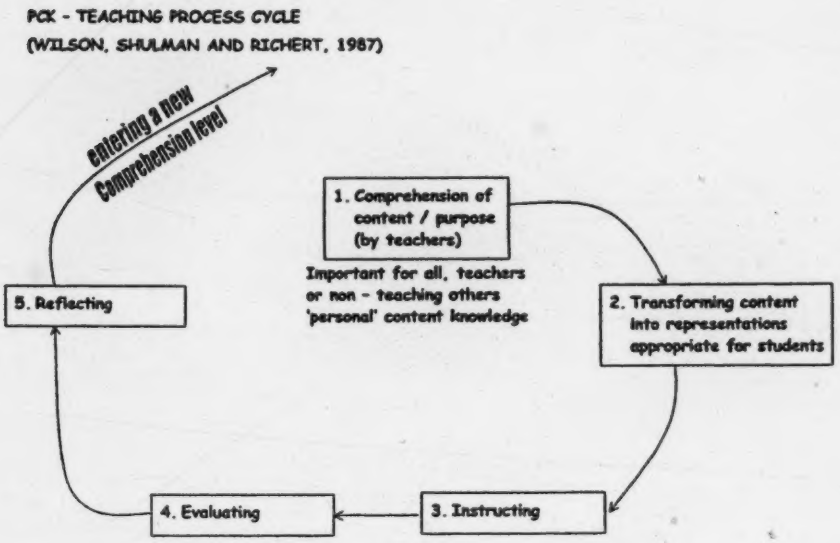
PT's description from her journal.
Topic: 'materials have mass'
Class: II (parellel section to yesterday's one).
I revised the previous lessons ... and started the lesson asking...
What is matter?
Then I asked states of matter then examples of each state then I asked the students if we buy milk how would we ask for it one student said 1 Kg but others said 1 L.
Then I explained that the solids are measured in Kg/g and liquid in L or ml. We measure the amount of mass if it is solid in Kg/g but if it is liquid in L or ml. Then I gave the same activity as yesterdays.
As this lesson was videod I thought that the students will not respond but when they started doing activity they didn't even get bothered about the camera.
I think today's lesson was little different from yesterday's because

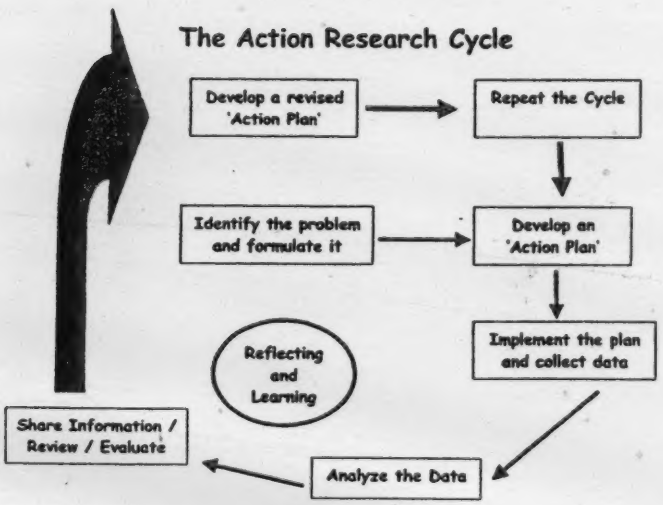
a) I made four groups.
b) I explained that mass can be measured in kg/l.

It is similar to yesterdays in that the activity was the same and the conclusion was the same.

Appendix 4

PCK-Teaching Process Cycle and Action Research Cycle


PCK - TEACHING PROCESS CYCLE
(WILSON, SHULMAN AND RICHERT, 1987)
entering a new Comprehension level
1. Comprehension of content / purpose (by teachers)
Important for all, teachers or non - teaching others 'personal' content knowledge
2. Transforming content into representations appropriate for students
3. Instructing
4. Evaluating
5. Reflecting


The Action Research Cycle
Develop a revised 'Action Plan'
Repeat the Cycle
Identify the problem and formulate it
Develop an 'Action Plan'
Implement the plan and collect data
Reflecting and Learning
Share Information / Review / Evaluate
Analyze the Data

Appendix 5a

PT's Grid: Sample

Date	Lesson on	Brief Description	Comments	Method	Lesson Learnt
26/9/2000 9:10 am 10:10 am	Materials have Mass (IIC)	Students will be able to tell the mass can be measured in different ways like Kg, g, l, ml, & there are weighing machines for solids and measuring cylinder for liquids	Ms. Charan asked me to make video of lesson tomorrow she didn't give me any comments	classify the different bottles, wrappers under the headings g, kg | Litre, ml, Solid | Liquid	One concept should be taken in one class [lesson] then the second concept. The students made a lot of noise
27/9/2000	Materials have mass (II B)	Same lesson as above	Video was made		I have to improve in classroom management; Lowering noise level; Questioning Skills
17/10/2000	Floating & Sinking	Co-teaching with Ms. Charan Motivation was done with the poem "Old Mac Donald had a farm" changed into "Old Mustafa had a farm" Then students were asked to draw a table in their sheets & then fill the table after finding out whether the object floats or sinks.	Making the table for class II is a difficult task. The students were unable to do it. So Ms. Charan promised to make the table for them and bring it in next period.	Students had to place different objects into a trough of water and find out if they float or sink and then tick it in respective columns. First predict then test it.	Motivation took more time than planned and the drawing of table sheet was very difficult for students of class II. The copy work & the entire activity was not completed in the period and was left for the next period. In SST programe I thought we're trained to complete all the planned work for 60 minutes in the stated time but now---
19/10/2000	Floating & Sinking	Same as previous		Students were provided with the worksheet & the students after testing were ticking the table yet copy work was not done! The porcelain trough made it difficult to see objects in it.	I was worrying about how I'll complete my syllabus if this will continue like this

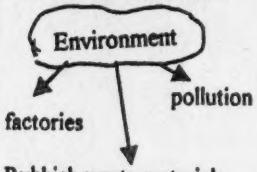
Appendix 5b

Nina's Grid: Sample

Date/time	Lesson on	Brief description	Purpose/Method of data collection	Comments	Lessons learnt by Nina and comments
12/1/2001 11:00 – 12:00 a.m. – noon	Enzymes and the effect of temperature	Reading material provided on enzymes shared by the students one group made a mind map on characteristics of enzymes and the other group on types of food as carbohydrates, proteins and fats and the reaction of enzymes and end products formed for each food category. Teacher student interaction through questions Chart prepared by the two groups for presentation. - Experimentation on starch digestion by salivary amylase - Effect of temperature on an enzyme reaction - Action of catalase and manganese dioxide on hydrogen peroxide.	Purpose of this lesson was to enhance students understanding of enzymes and their specific properties and how they react. Lesson plan; Choosing of related experiments; audio tape reflection Reading material from other books condensed as one material on enzymes .	- Too much in 60 min. - ---- -- Students and teacher talked simultaneously. - Communication among students while performing experiment was not appropriate. - Equal attention not given to all the students	- This lesson was to be given on 15/12/00 but due to early closing of school for the winter vacations I could not do it. However, I got a good chance of discussing this lesson plan with Charan and her suggestions proved to be one of the reasons for this lesson to be successful. - During performance of steps of experiment students should be asked to explain after completion of a test. Following Charan's suggestions I was able to complete most of the experiments in the required time which I was not able to do previously. All activities to be performed were checked and performed before the students started with the lesson... another reason for the lesson to be successful Students were happy and comfortable as they could make the observations of all these experiments.

Appendix 5c

Saira's Grid: Sample

Date/Time	Lesson On	Brief Description	Purpose/Method of Data Collection	Comments	Lesson Learnt by Saira and Comments
(7) 20-12-2000 12:20 - 1:30 p.m.	Lesson: Pollution: (Classification of bio/non-bio degradable)	- Some students shared their previous given task with class. Ask question why do you collect all reparts from school ground? The explore the topic Environment. - Through mind map they elicited their ideas about  Rubbish waste materials - Teacher got their ideas through charts representatives. Then she explained through some waste samples which can recycle naturally and some cannot. - Classification of waste materials by chalk/board representation. - Conclusion: Check their learning by gave them worksheet. Home task: Mark ✓ which picture is related to our environment.	Purpose: To know about environment and which factors are effected to environment and make it polluted. - Definition of Bio and Non-bio degradable materials (some are naturally recycle) Method: Warm up activities sharing in group chart representative worksheets - lesson plan / Audio tape, explanation through sample of waste materials.	- Some satisfaction because everything was gone accordingly. - Actively participation of students. - Less teacher talk more students involvement. - students followed social skills listened- tried to understand and then shared with class.	- Through Teacher Action Cycle. Make myself comfortable in sense that each and every step is clear to me with all instruction. - I could listen to everyone easily. - Time allocated went well I had much time to explain to them even the home task comfortably.

Note: R in this context is for "researcher"

Appendix 6

PT's students' sample work 'Floating and Sinking'

Name ____ Class II

Date 19-10-2000

FLOATING AND SINKING

Table

Object	Prediction			Observation	
	float	sink	Not Sure	float	sink
Feathers	✓			float	
stones		✓		float	sink
Match stick	✓			float	
Wood	✓			Float	
steel spoon		✓			sink
Plastic spoon	✓			Float	
fruit		✓			sink

1) The objects that float

2) The objects that sink

Name ____ Class II

Date 19-10-2000

FLOATING AND SINKING

Table

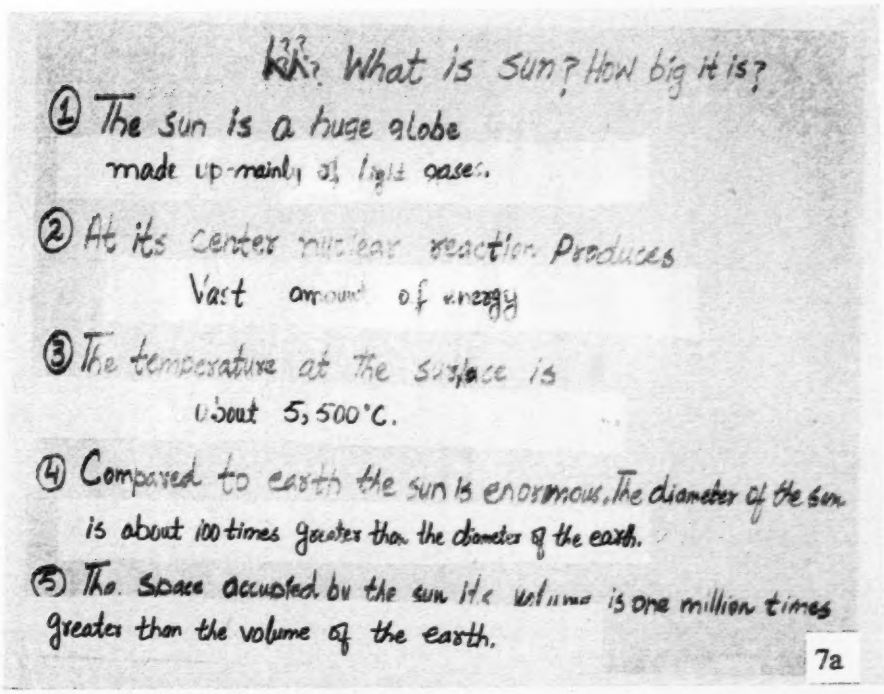
Object	Prediction			Observation	
	float	sink	Not Sure	float	sink
Feathers	✓			✓	
Stone		✓			✓
Match Sticks	✓			✓	
Wood	✓			✓	
Steel Spoon		✓			✓
Plastic Spoon	✓			✓	
Fruits					

1) The objects that float

2) The objects that sink

Appendices 7a and 7b

Saira's students' sample work 'the Sun and the Moon'



What is sun? How big it is?

① The sun is a huge globe made up mainly of light gases.

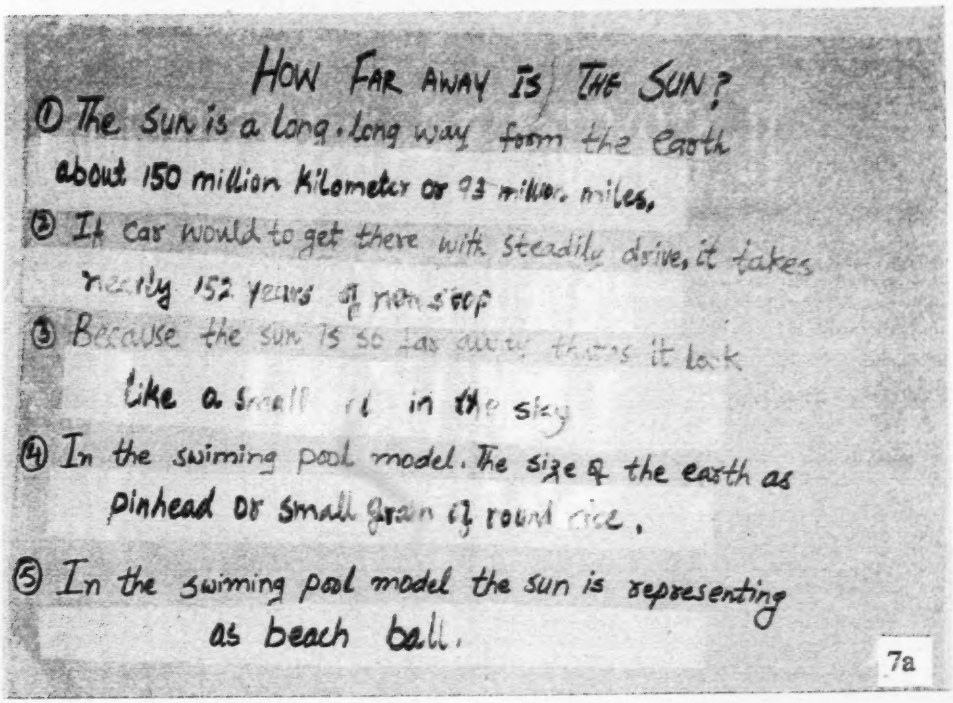
② At its center nuclear reaction Produces Vast amount of energy

③ The temperature at the surface is about 5,500°C.

④ Compared to earth the sun is enormous. The diameter of the sun is about 100 times greater than the diameter of the earth.

⑤ The space occupied by the sun its volume is one million times greater than the volume of the earth.

7a



HOW FAR AWAY IS THE SUN?

① The sun is a long, long way from the earth about 150 million kilometer or 93 million miles.

② If car would to get there with steadily drive, it takes nearly 152 years of nonstop

③ Because the sun is so far away thing it look like a small ball in the sky

④ In the swiming pool model. The size of the earth as pinhead or small grain of round rice.

⑤ In the swiming pool model the sun is representing as beach ball.

7a

THE MOON AND GRAVITY

① The moon is Large body and has a Lot of mass.

② Many people think that there is no gravity on the moon.

③ The force of gravity on the moon is much less than on the earth. Because the moon is both less massive and smaller.

④ If the astronaut lets go of the ball, It is pulled to the surface of the moon by the force of the moon's gravity.

⑤ Because the force is much smaller than it would be on earth the ball falls much more slowly.

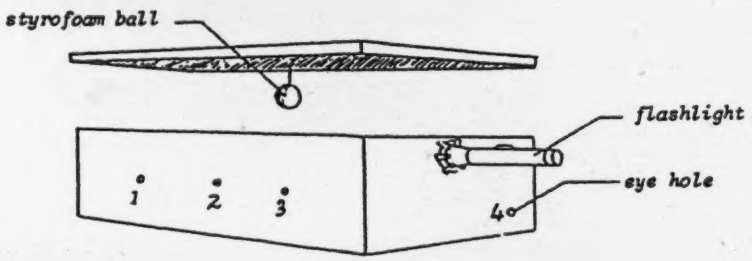
7a

7b

Appendix 8

Shoe Box Activity: What causes the phases of the Moon?

Materials: 1. A large shoe box, carbon paper or other black paper.
2. A styrofoam ball (about 5 cm in diameter).
3. A small strong flashlight, masking tape, black thread.



Procedure:

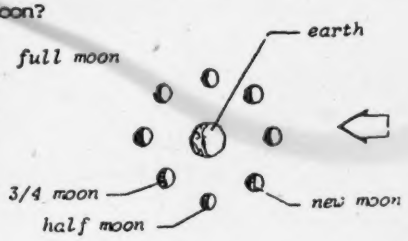
1. Cover the inside of the shoe box with black paper by gluing or placing small rolls of masking tape between the paper and the box.
2. Suspend the styrofoam ball from a black thread of about 2 cm long, and tape the thread against the center of the lid (see sketch).
3. Cut a hole the size of the flashlight at the end of the box and seal any space around it with masking tape.
4. Make 8 eye holes in the sides of the box: three on each long side and one at the end of the box obliquely under the flashlight,
5. Put the lid with the suspended ball on the box and seal the edges around it with masking tape.
6. Look through the eye holes and observe the ball (with the flashlight on) in the order numbered in the sketch.

Questions:

1. What do you see when you look through the eye holes?
2. Turn the flashlight off; what do you see through the eye holes?
3. Looking through which of the holes gives you a similar picture as looking at the new moon?
4. What is it that causes the phases of the moon?

Explanation:

Perhaps the best way to explain seeing the eight different phases of the moon is the illustration on the right. A quarter new moon would correspond with looking through hole 1, half moon and three quarter moon with looking through hole 2,3 full moon with looking through hole 4, etc.



Source: Liem, L. T. (1987)
Invitation to Science Inquiry

Appendix 9

SIGHTING OF THE MOON IN KARACHI:
"SCIENCING" ACTIVITY

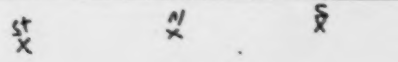
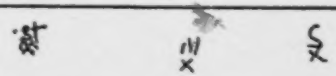
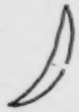
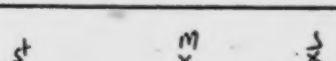
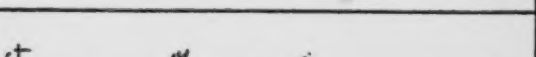
Moon watching is fun and you can learn more about moon phases by actually doing the activity and recording your observations. This can then help you to share and discuss your findings about phases of the moon. Please complete the following table over one full cycle of the moon commencing on the first day of sighting of the moon for the month of Ramadan.

Date	Time of sighting (e.g. 17:30 hrs)	Diagram of Moon's shape	Name of stage in the cycle	Diagram to show positions of the Earth (E), Sun (S), and Moon (M), for each sighting, and your position on earth as the observer (Std)	Weather conditions (e.g. cloudy, rainy)
Nov. 26					
Nov. 27					
Nov. 28					
Nov. 29					

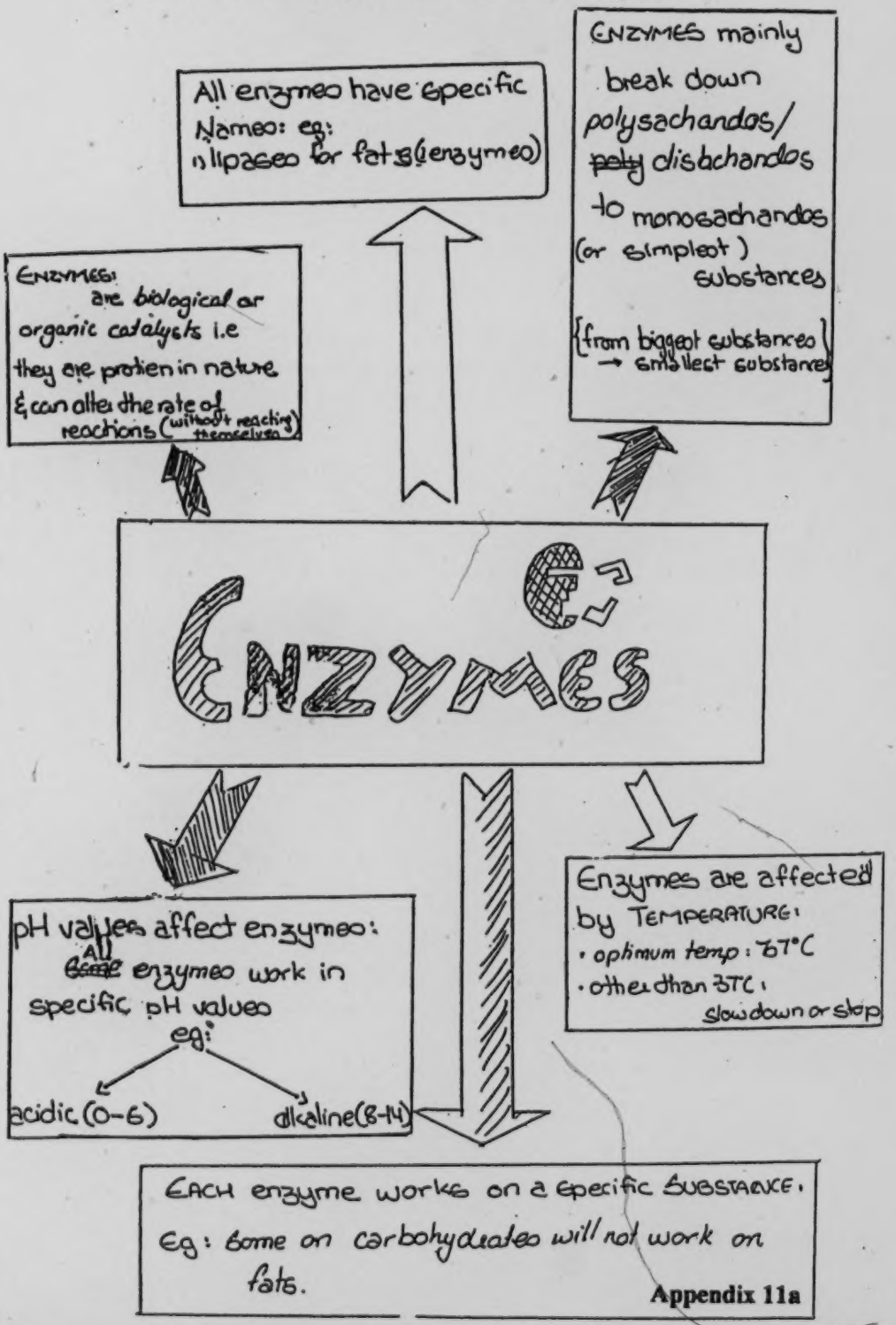
Appendix 10

SIGHTING OF THE MOON IN KARACHI:
"SCIENCING" ACTIVITY

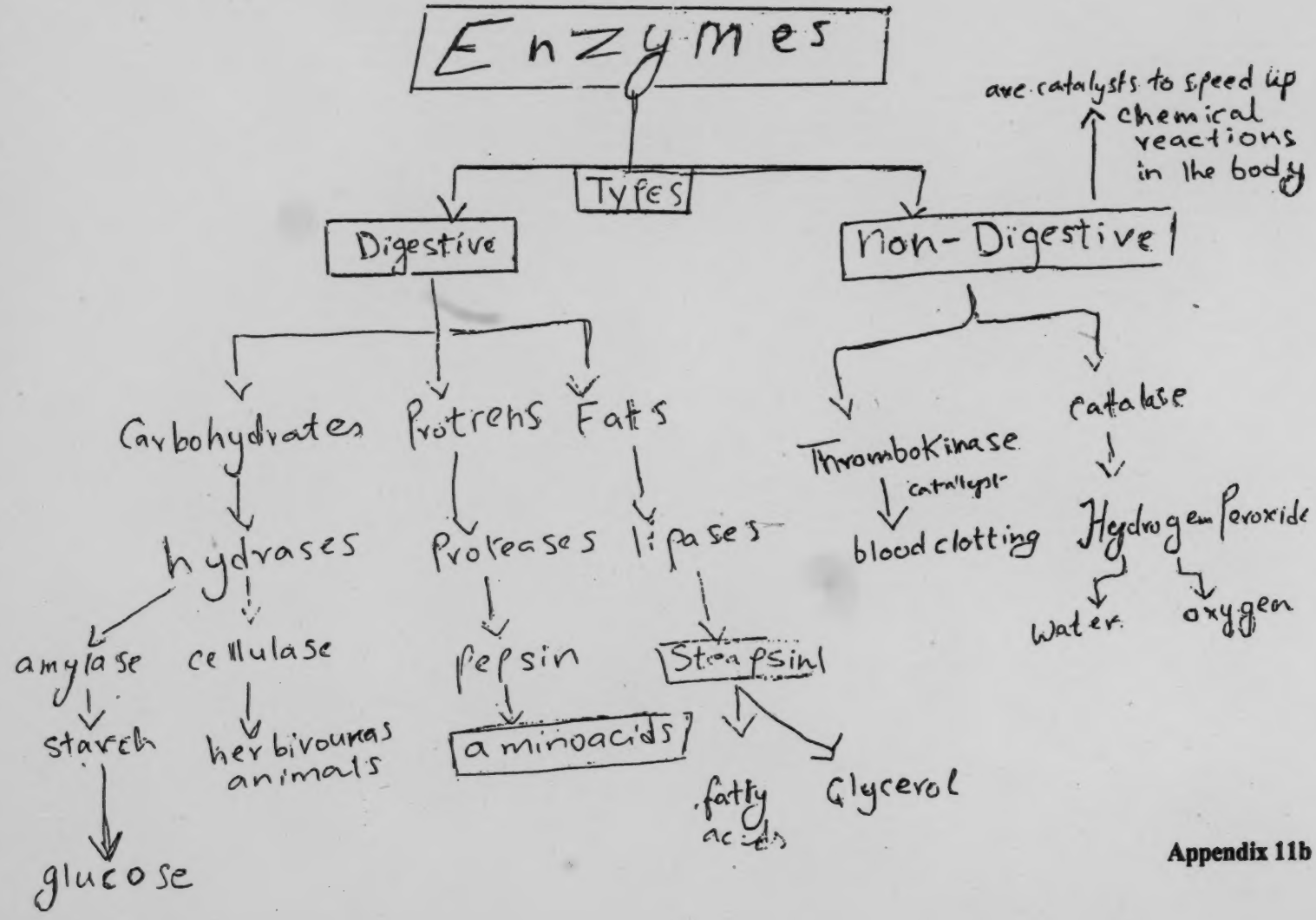
Moon watching is fun and you can learn more about moon phases by actually doing the activity and recording your observations. This can then help you to share and discuss your findings about phases of the moon. Please complete the following table over one full cycle of the moon commencing on the first day of sighting of the moon for the month of Ramadan.

Date	Time of sighting (e.g. 17:30 hrs)	Diagram of moon's shape	Name of stage in the cycle	Diagram to show positions of the Earth(E), Sun(S) and Moon(M), for each sighting, and your position on earth as the observer (Std)	Weather conditions (e.g. cloudy, rainy)
Nov. 26	—	—	—	—	—
Nov. 27	6:45		New moon		cloudy
Nov. 28	5:0'clock		first moon		Sky clear
Nov. 29	5:45		Crescent moon		Sky clear
Nov. 30	5:0'clock		waxing crescent		Sky clear

Appendices 11a and 11b
Nina's students' sample work 'Mind Maps Enzymes'


All enzymes have specific Names: eg:
lipases for fats (enzymes)
ENZYMES mainly break down polysachandos/ ~~poly~~ disbachandos to monosachandos (or simplest) substances
{from biggest substances → smallest substances}
ENZYMES:
are biological or organic catalysts i.e they are protien in nature & can alter the rate of reactions (without reacting themselves)
ENZYMES
pH values affect enzymes:
All ~~some~~ enzymes work in specific pH values
eg:
acidic (0-6)
alkaline (8-14)
Enzymes are affected by TEMPERATURE:
• optimum temp: 37°C
• other than 37C: slow down or stop
EACH enzyme works on a specific SUBSTANCE.
Eg: some on carbohydrates will not work on fats.

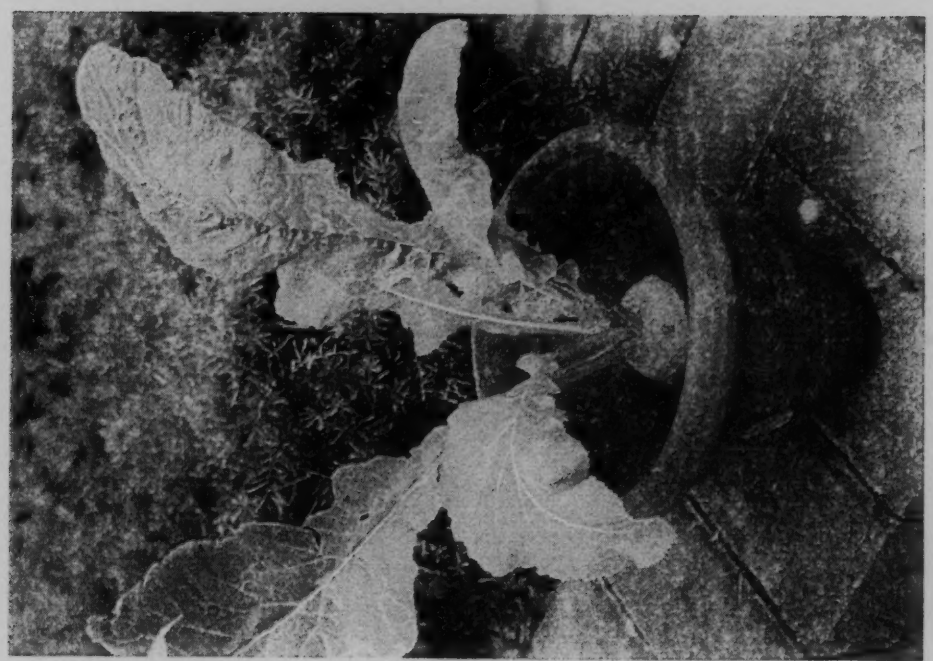
Appendix 11a



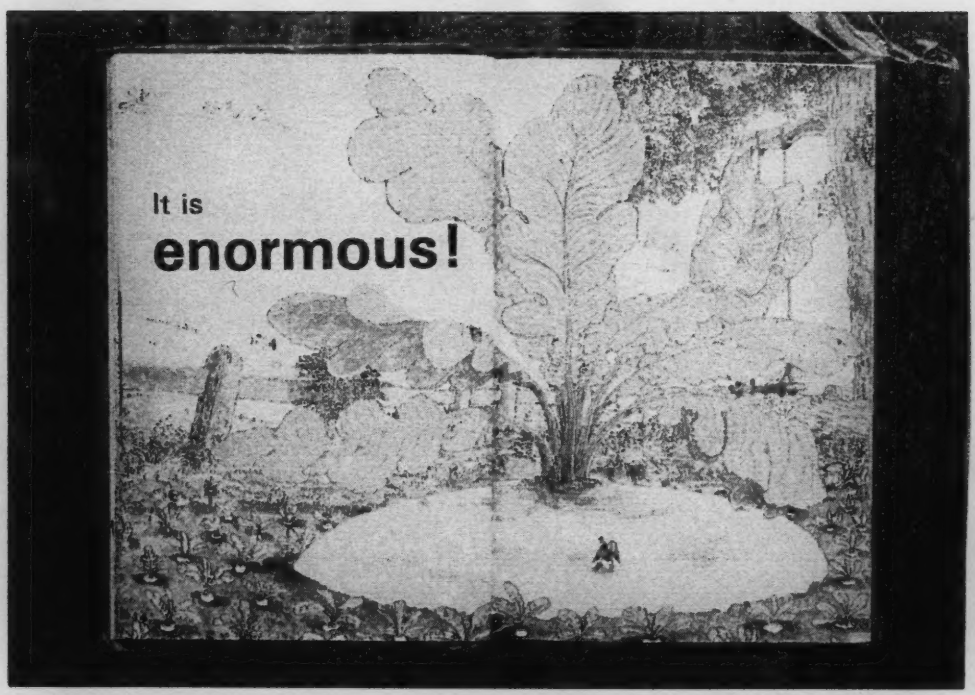
Appendix 11b

Appendix 12a
The Twisted Carrots

Appendix 12b
A Potted Turnip



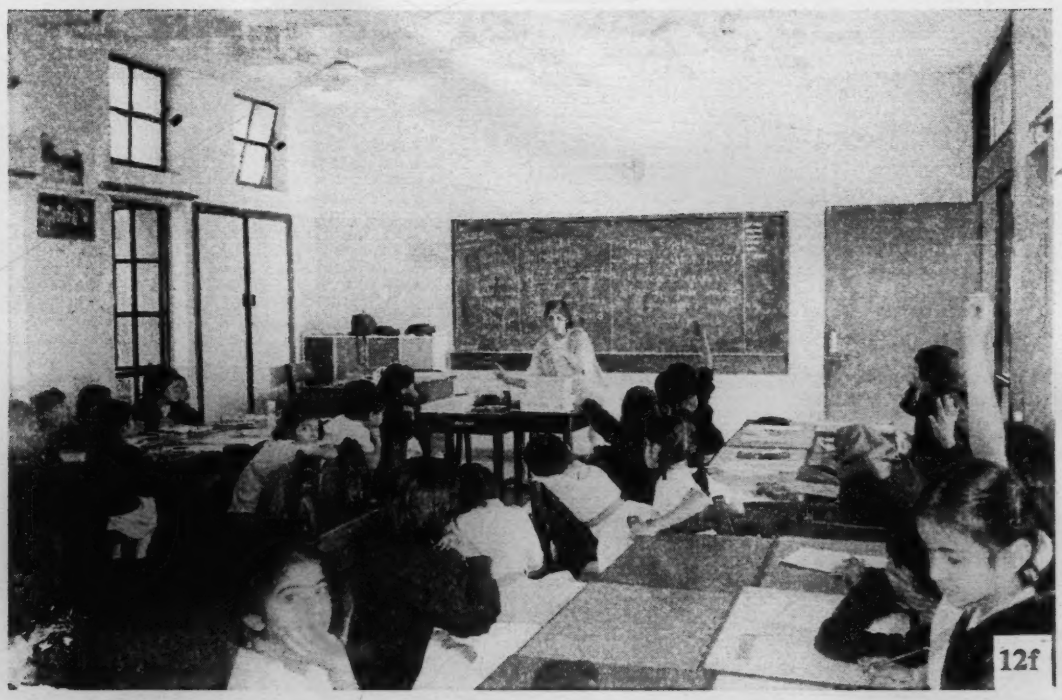
Appendix 12c
Enormous Turnip

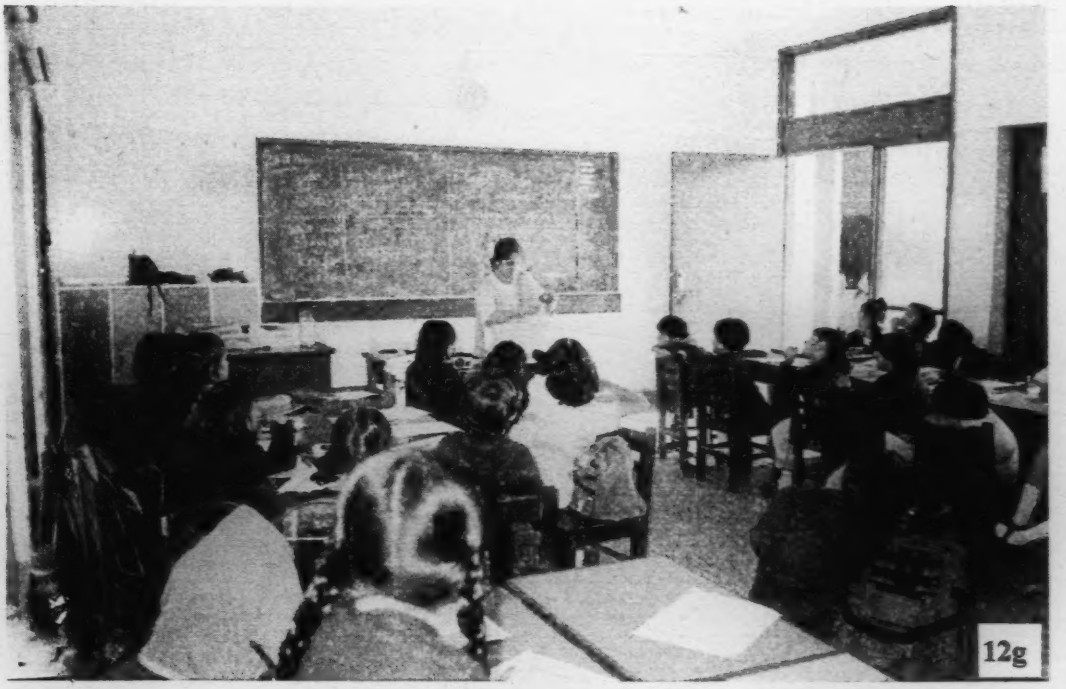


Appendix 12d
PT's Student Poking the Potted Turnip

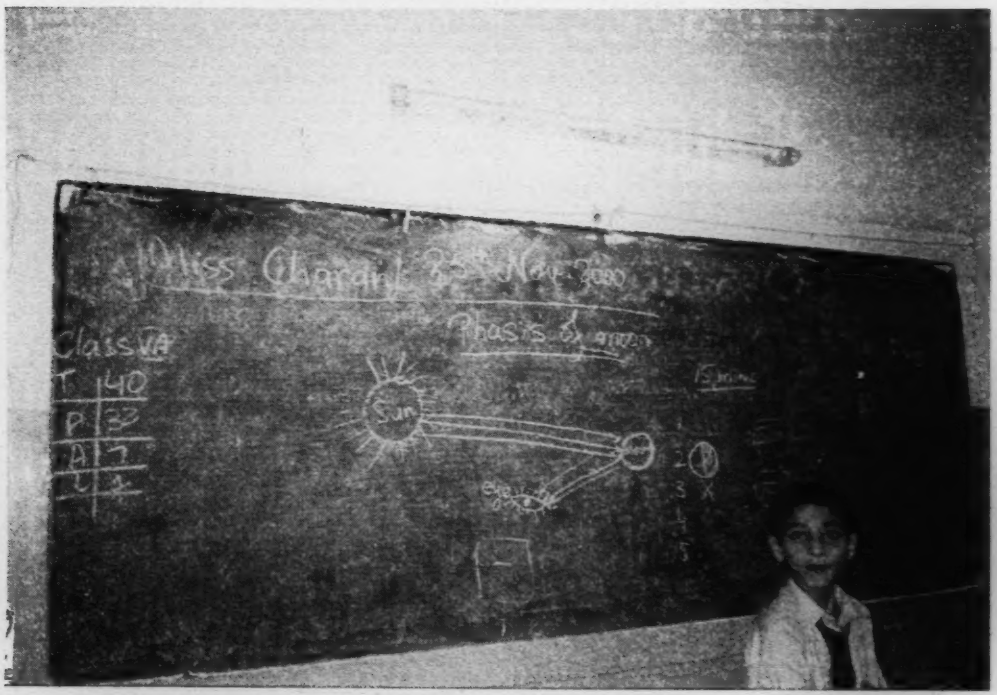
Appendices 12e-g
The Dancing Dolls demonstration

12e


12f



Appendix 12h
Saira's Lesson 'Phases of the Moon' Ray Diagram



Appendices 13a-c
Saira's students' sample work 'Environment Unit'

Traffic survey: 1

✣ Conduct a survey of the traffic near your school.
Make a tally of the vehicles that you see.

Date: 2nd Jan 2001
Location: Outside to the school **Time:** 3:45pm

Type of vehicle	Tally	Total
bicycle	1111111 4 - 11 1 1 1 1 1 1 1 1	18 Cycle
motor cycle or scooter	10 8 6 5 3 4 4 4 3	48 motor
car – carrying one person	1 1 1 1 1 5	10 car
car – carrying two people	1 1 1 1 1 1 1 1 6 8	22 cars
car – carrying more than two people	1 1 1 1 1 1 1 8	15 Cars
van	2 5 5 2 2	16 Van
lorry	6 1	7 lorry
bus	3 3 5 4 5 5	25

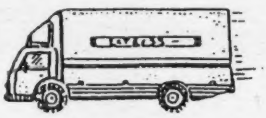
Appendix 13a

People and their communities
Traffic survey: 1

Name _____

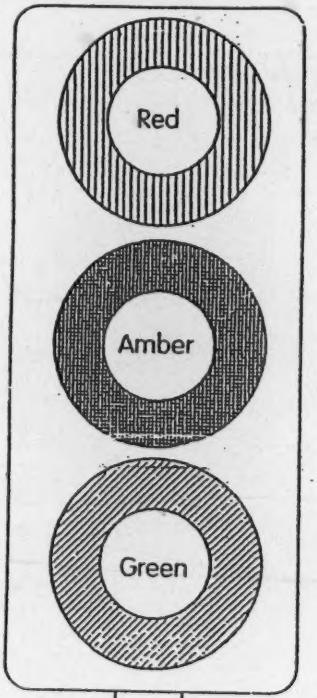
Teacher Timesavers: Environmental studies

Traffic survey: 2



✣ Use your traffic survey to complete this sheet.

• Which type of transport is the most common?
For Public transport Bus, Mini Bus & Motor Cycles are the most common transport



• Which types of transport are bad for our environment? Heavy Trucks, Lorries Rickshaws and Train.
Why? Heavy Pressure horns, black smokes and large number of exidents.

• Which types of transport are designed with the environment in mind? No this type of transport is not seen
How? _____

• Which type of transport is best for our environment? Small baby prams, bicycle and boat.
Why? Physically and mentaly harmless, non-poluted, and Cheap in use.

• List some ways of lessening the traffic in your area. Put a * next to those things you could do something about.

1. Timing of vehicles in area.
2. Traffic Police to control Traffic
3. Smooth running of vehicles i.e. not more stops
4. Proper arrangment of Parking.

Appendix 13b

Journey to school

✣ Ask the children in your class how they travel to school and fill in this tally chart.

walk	24	car	2
cycle	-	bus	-
train	-	other	10

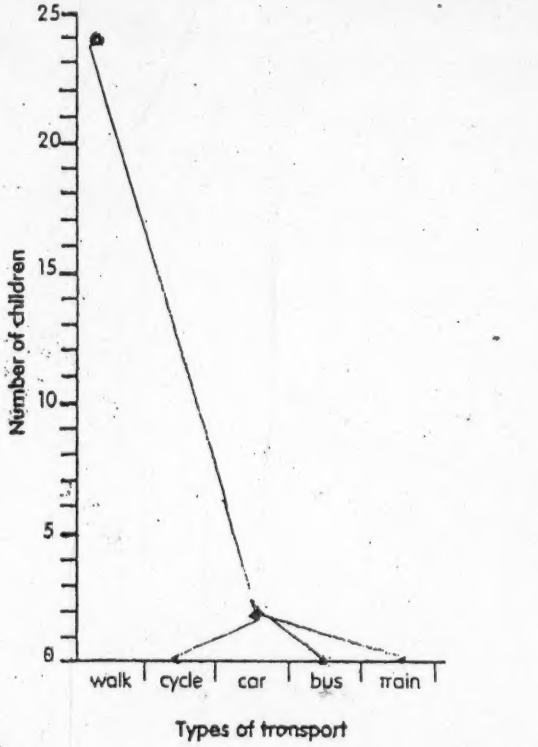
✣ Use your tally chart to complete the bar graph opposite.

✣ Now answer these questions:

• Which types of transport are better for our environment?

• How many people in your class live close enough to school to walk or cycle but still travel by car?

• If cars must be used, suggest ways of using them that would be better for the environment.

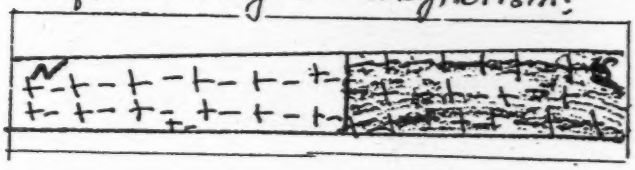


Appendix 13c

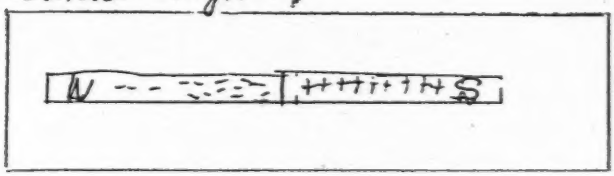
Appendix 14
Saira's students' sample work 'Magnets'

Normal Magnet:

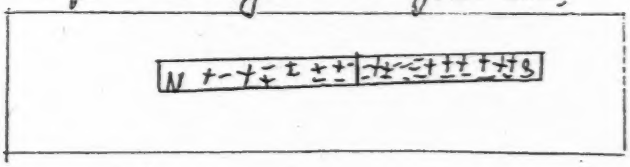
After loosing the magnetism:



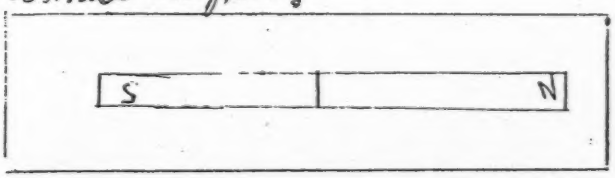
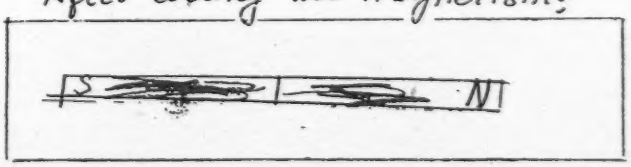
Normal Magnet:



After loosing the magnetism:



Normal Magnet:



After loosing the magnetism: